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DEPARTMENT OF THE INTERIOR AND RELATED AGENCIES APPROPRIATIONS FOR 1978

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

NINETY-FIFTH CONGRESS

FIRST SESSION

SUBCOMMITTEE ON THE DEPARTMENT OF THE INTERIOR AND RELATED AGENCIES

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PART 8

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Printed for the use of the Committee on Appropriations

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DEPARTMENT OF THE INTERIOR AND RELATED AGENCIES APPROPRIATIONS FOR 1978

MONDAY, APRIL 25, 1977.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

WITNESS

ROBERT W. FRI, ACTING ADMINISTRATOR

SUPPORTING WITNESSES

DR. GENE G. MANNELA, ACTING ASSISTANT ADMINISTRATOR FOR CONSERVATION
DR. PHILIP C. WHITE, ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY
DR. JAMES L. LIVERMAN, ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY
DENNIS R. SPURGEON, ACTING ASSISTANT DIRECTOR FOR REPROCESSING, DIVISION OF WASTE MANAGEMENT, PRODUCTION AND REPROCESSING
M. C. GREER, CONTROLLER

Mr. YATES. The hearing will come to order.

Today we have the appropriation for the U.S. Energy Research and Development Administration with respect to its request for funds to carry on its fossil fuel and end use conservation activities.

In support of that appropriation we have with us Mr. Robert Fri, the Acting Administrator; Dr. Gene Mannella, Acting Assistant Administrator for Conservation; Dr. White, Assistant Administrator for Fossil Energy; Dr. Liverman, Assistant Administrator for Environment and Safety; and Mr. Spurgeon, Acting Assistant Director for Reprocessing, Division of Waste Management, Production and Reprocessing.

I read Dr. White's statement over the weekend. I didn't read Mr. Fri's statement because I didn't have it.

How long a statement do you have?

Mr. FRI. I have a 15-minute statement. I would be happy to highlight it.

Mr. YATES. Let's put your statement into the record and let's put Dr. White's statement and the amended budget justification into the record.

[The statements follow:]

STATEMENT OF ROBERT W. FRI
ACTING ADMINISTRATOR
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 APPROPRIATIONS HEARINGS

Mr. Chairman and members of the Committee:

I appreciate the opportunity to appear before you today to discuss the Energy Research and Development Administration's request for appropriations for fiscal year 1978.

Last Wednesday President Carter outlined a National Energy Plan creating the framework for solving our national energy problems. The President's plan has fully integrated RD&D activities into an overall approach which employs the full set of tools - regulatory, economic, and technological - necessary to deal with this country's most serious current problem.

The President discussed three major strategies for achieving the objectives of the Plan:

— Implementation of an effective conservation program for all sectors of energy use so as to reduce the rate of demand growth to less than 2 percent.

— The conversion by industry and utilities using oil and natural gas to coal and other more abundant fuels to reduce imports and make natural gas more widely available for household use.

— A vigorous research and development program to provide renewable and essentially inexhaustible resources to meet United States energy needs in the next century.

In support of this Plan, ERDA's 1978 budget request has been further amended. Chart I summarizes the budget changes from the initial submission last January to our present request. As you can see from the table, the February revisions increased significantly ($247 million) the budget request for efforts on nearer-term technologies--conservation, fossil and solar heating and cooling. The additional funding for these efforts was offset by reductions in long term programs such as the nuclear breeder, fusion and solar electric applications.

The President is now requesting further budget increases for key nonnuclear ERDA programs. The current revision emphasizes small scale energy systems in the solar and geothermal categories ($28 million) in addition to further increases for fossil ($17 million) and conservation ($7 million). Funding for these additional efforts is offset by reductions and adjustments in the nuclear program.

We are now requesting appropriations totaling $7,305 million, of which $5,420 million is for operating expenses, and $1,714 million is for plant and capital equipment. Revenues, primarily from uranium enrichment activities, are estimated at $1,067 million assuming passage of necessary legislation to revise our charges for enriching services. Accordingly, total resources of $8,372 million will be available to ERDA in 1978. An analysis of our total budget by major functional areas is shown in charts II and III. Of particular interest is our energy RD&D budget, a breakdown of which is shown in charts IV and V. Programs under the jurisdiction of this Committee are shown in charts VI and VII.

Accomplishments

Before going into the budget in detail, I would like to briefly review some of the major accomplishments of ERDA in the past year for programs of interest to your Committee. There has been significant progress in our energy RD&D programs.

In Fossil Energy:

- Construction has begun on two major coal R&D facilities: the H-Coal liquefaction pilot plant in Catlettsburg, Kentucky, and the Component Development and Integration Facility for magnetohydrodynamics (MHD) in Butte, Montana.

- Construction has been completed on two other facilities: The BiGas high Btu gasification pilot plant in Homer City, Pennsylvania, and a 30 MW fluidized-bed boiler for direct burning of coal in Rivesville, West Virginia.

- A total of 35 field projects, cost shared with industry, are now underway to test promising methods of increasing oil and gas recovery in existing reservoirs.

- A contract has been awarded to test technology for in-situ recovery of Antrim oil shales in Michigan and negotiations are underway for demonstration of modified in-situ and other promising technologies in western oil shales.

- An underground coal gasification test in Wyoming produced enough gas to generate electricity to supply the daily electrical needs of a town of about 6,000 people.

In our Conservation program:

- o During this period we successfully completed a durability test on the baseline gas turbine engine. The engine accumulated the equivalent of over 150,000 miles under stringent test conditions.

- o We have completed the design on and broken ground for a pilot scale plant to produce methane from urban wastes by anaerobic digestion.

- o We have also entered into a joint ERDA/industry program to develop fuel cells. System design has been completed on a 4.8 MW fuel cell power plant and design confirmation is proceeding.

- o Two experimental homes designed to use less than half the energy of conventional homes were completed in September in Mission Viejo, California. These homes include not only energy saving features, but also solar assisted hot water and space heating and cooling.

1978 Programs

Mr. Chairman, I would now like to turn to a discussion of our major program thrusts for 1978. The programs under the jurisdiction of this Committee total $1,192 million, including $300 million for the legislative proposal for the Alternative Fuels Demonstration Program. This represents an increase of $608 million over the 1977 level.

The following are highlights of major program increases:

Conservation Research and Development

End use conservation and improved efficiency technologies are a key element of our efforts to reduce energy demand in the near- and mid-term. The 1978 request of $235 million is $134 million above the 1977 level.

Increases in buildings and community systems will allow continuation of existing demonstration projects with near-term objectives. The Annual Cycle Energy System (ACES) technology will be emphasized in multi-family and commercial buildings and increases will be provided for performance standards and efficient light sources.

In the industry conservation area, new efforts will be initiated on energy integrated industrial parks, dewatering techniques in the paper-making processes; direct reduction of aluminum from ore; and increased energy efficiency in food processing and preservation.

In the transportation area, the budget includes $40 million to support the Electric and Hybird Vehicle Act of 1976. Increases are also provided for the development of more efficient and fuel-flexible heat engines, including testing of advanced gas turbines. In addition, under improved conversion efficiency, the development of fuel cells for generation of electricity will continue, including the completion of fabrication of a 4.8 MW demonstration module.

Included in this request is $7 million for additional Conservation energy initiatives resulting from the President's National Energy Plan. Activities include acceleration of two efforts which promise to increase the efficiency of existing fuel usage--specifically, gas fired heat pumps and the fuel cell. In addition, a new Conservation funded effort concerned with investigating the utilization of waste heat from ERDA's gaseous diffusion plants and production reactors is included. Successful demonstration of this application could be of significant benefits to communities and industries located adjacent to these facilities, as well as providing desirable stimulus for similar applications in the private sector.

Energy Extension Service

Funds were appropriated in 1977 to initiate the first year of a two-year pilot Energy Extension Service program. An additional $8 million is requested in 1978 to complete the pilot projects, to assess the results, and to evaluate the potential effectiveness of broader extension service applications.

FY 1977 Reprogramming Request

On April 6, 1977, I forwarded to the Committee a 1977 reprogramming request in the amount of $25 million. The purpose of this request was to provide funding for the development and implementation of energy performance standards for new buildings as authorized by the Energy Conservation and Production Act of 1976, and for the implementation of the Electric and Hybrid Vehicle Act of 1976. The 1978 budget request before you assumes a favorable response by the Congress to the reprogramming request.

Fossil Energy Development

In 1978, our Fossil Energy Development programs will increase 36 percent in budget authority, from $483 to $657 million. This increase will continue accelerated development and demonstration of technology to substitute coal and coal-derived fuels for increasingly scarce oil and gas, to increase fossil fuel conversion efficiencies through advanced power conversion systems, to apply enhanced recovery methods to known sources of oil and gas, and to recover shale oil resources. Major increases in the coal R&D program include funds to continue construction of two liquefaction pilot plants and a low-Btu gasification combined cycle pilot being cost shared with industry, and the start of a new high-Btu gasification pilot also to be cost shared with industry. Our request also includes two new small industrial gasifiers and a new SRC demonstration plant. The magnetohydrodynamics (MHD) program will begin larger scale development, testing, and integration of components in the new facility currently being constructed in Montana.

In oil and gas recovery, the major increase is to support field tests, either ongoing or planned. These efforts are directed at increasing the recovery of petroleum and natural gas from resources which are presently not economically exploitable. Efforts include enhanced gas recovery from the Devonian shale in the East. Increases in oil shale and in-situ technology programs allow for funding of five processes for in-situ shale oil recovery and for continuation of field experimentation in several promising in-situ coal gasification technologies.

The President's energy initiative package includes $17 million for additional Fossil Energy programs. Efforts associated with recovery of natural gas from devonian shales are accelerated and design activities for a new solvent refined coal demonstration plant are initiated. The Devonian shale resource is particularly attractive because of its close proximity to large population centers in the fuel scarce midwest and northeast regions. The solvent refined coal process has been operating satisfactorily for over two years and a scale up of the process is feasible with moderate technical risk.

Alternative Fuels Demonstration Program

Apart from the regular budget request for Fossil Energy, the budget includes a legislative program to be submitted at a later date which will request approval of financial incentives for selected individual

alternative fuel projects. These commercial demonstrations will be individually selected on a case-by-case basis to best provide environmental, regulatory, socioeconomic, and market information for future development of alternative fuel production capability by private industry.

In summary, the ERDA programs requested in 1978 offer a reasonable and balanced program in energy RD&D and other activities, building on the accomplishments of the past two years. We intend to continue to pursue a vigorous R&D program to provide the energy options that are so vital to our Nation's health and well being.

I appreciate this opportunity to appear before you today and I would be pleased to respond to any questions you may have.

CHART I

FY 1978 CARTER REVISION TO FORD ENERGY BUDGET

(Budget Authority, $ In Millions)

	Ford Budget Jan 1977	Carter Revision Feb 1977	Carter Revision Apr 1977
Conservation	$ 158	$ 318	$ 325
Fossil Energy	598	640	657
Light Water Reactors	642	617	548
Solar Heating and Cooling	45	90	96
Solar Electric and Other	260	215	224
Geothermal Energy	88	88	101
Fusion	513	433	433
Advanced Reactor & Fuel Cycle Concepts	998	799	685
Total	$3,302	$3,200	$3,069

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CHART II

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

FY 1978 BUDGET REQUEST

	BUDGET AUTHORITY (IN MILLIONS)				
			1978		
	1976	1977	January	February	April
I. Energy Research, Development & Demonstration					
Energy RD&D Programs	$1,657	$2,600	$3,303	$3,201	$3,069
Supporting Research	288	345	385	390	391
Financial Incentive Activities	0	30	325	330	330
Subtotal	1,945	2,975	4,013	3,921	3,790
II. Basic Research and Technology Development					
High Energy Physics	182	224	269	269	269
Nuclear Physics	74	81	86	86	86
Life Sciences and Biomedical Applications.	41	44	39	39	39
Naval Reactor Development	227	200	243	243	243
Space Applications and Other	23	24	36	36	35
Subtotal	547	573	673	673	672
III. Uranium Enrichment Activities					
Uranium Enrichment Activities	949	1,482	1,685	1,685	1,361
Revenues	-629	- 699	-966	-966	- 966
Subtotal	320	783	719	719	395
IV. National Security					
Weapons Activities	1,057	1,184	1,466	1,466	1,468
Special Materials Production	398	551	671	671	671
Subtotal	1,455	1,735	2,137	2,137	2,139
V. Program Management and Support	248	293	298	303	309
Grand Total	$4,515	$6,359	$7,840	$7,753	$7,305

CHART III

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

FY 1978 BUDGET REQUEST

	BUDGET OUTLAYS (IN MILLIONS)				
			1978		
	1976	1977	January	February	April
I. Energy Research, Development & Demonstration					
Energy RD&D Programs	$1,260	$2,144	$2,737	$2,736	$2,706
Supporting Research	260	318	360	362	363
Financial Incentive Activities	0	4	10	10	10
Subtotal	1,520	2,466	3,107	3,108	3,079
II. Basic Research and Technology Development					
High Energy Physics	173	200	237	237	237
Nuclear Physics	63	75	84	84	84
Life Sciences and Biomedical Applications	38	42	38	38	38
Naval Reactor Development	230	241	248	248	248
Space Applications and Other	25	24	30	30	29
Subtotal	529	582	637	637	636
III. Uranium Enrichment Activities					
Uranium Enrichment Activities	804	1,246	1,447	1,407	1,315
Revenues	-669	-699	-966	-966	-966
Subtotal	135	547	481	441	349
IV. National Security					
Weapons Activities	1,006	1,146	1,316	1,316	1,318
Special Materials Production	329	442	597	597	597
Subtotal	1,335	1,588	1,913	1,913	1,915
V. Program Management Support	240	168	306	306	310
Grand Total	$3,759	$5,351	$6,444	$6,405	$6,289

CHART IV

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

FY 1978 BUDGET REQUEST

	BUDGET AUTHORITY (IN MILLIONS)				
			1978		
	1976	1977	January	February	April
I. Energy Research, Development & Demonstration					
Conservation	$ 76	$ 161	$ 158	$ 318	$ 325
Fossil Energy	426	483	598	640	657
Solar Heating and Cooling	39	86	45	90	96
Solar Electric and Other	76	204	260	215	224
Geothermal Energy	31	55	88	88	101
Fusion Power Development	246	428	513	433	433
Liquid Metal Fast Breeder Reactor	505	686	855	656	483
Nuclear Fuel Cycle & Safeguards	167	357	636	611	587
Other Fission	84	140	148	148	161
Special Foreign Currency Funds	7	0	2	2	2
Subtotal	1,657	2,600	3,303	3,201	3,069
II. Supporting Research					
Environmental and Biomedical Research	156	189	210	215	216
Basic Energy Sciences	132	156	175	175	175
Subtotal	288	345	385	390	391
III. Financial Incentive Activities					
Geothermal Resources Development Fund	0	30	30	30	30
Alternative Fuels Demonstration Program	0	0	295	300	300
Subtotal	0	30	325	330	330
Total Energy Research, Devel. & Demo. Prog.	$1,945	$2,975	$4,013	$3,921	$3,790

CHART V

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

FY 1978 BUDGET REQUEST

ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

	BUDGET OUTLAYS (IN MILLIONS)				
			1978		
	1976	1977	January	February	April
I. Energy RD&D Programs					
Conservation	$ 45	$ 125	$ 139	$ 244	$ 249
Fossil Energy	242	445	500	519	531
Solar Heating and Cooling	15	61	61	86	90
Solar Electric and Other	48	122	173	164	170
Geothermal Energy	30	49	68	68	78
Fusion Power Development	211	328	431	392	392
Liquid Metal Fast Breeder Reactor	441	595	736	651	589
Nuclear Fuel Cycle and Safeguards	143	300	491	474	458
Other Fission	85	117	135	135	146
Special Foreign Currency Funds	0	2	3	3	3
Subtotal	1,260	2,144	2,737	2,736	2,706
II. Supporting Research					
Environmental and Biomedical Research	142	181	198	200	201
Basic Energy Sciences	118	137	162	162	162
Subtotal	260	318	360	362	363
III. Financial Incentive Activities					
Geothermal Resources Development Fund	0	4	7	7	7
Alternative Fuels Demonstration Program	0	0	3	3	3
Subtotal	0	4	10	10	10
Total Energy Research, Devel. & Demo. Prog.	$1,520	$2,466	$3,107	$3,108	$3,079

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CHART VI

REVISED FY 1978 ERDA BUDGET TO CONGRESS

PROGRAMMATIC EFFORT UNDER THE JURISDICTION OF THE SUBCOMMITTEE ON INTERIOR

	Budget Authority ($ In Millions)		
	1976	1977	1978
I. Energy Research, Development & Demonstration			
Conservation	$ 37	$ 101	$ 235
Fossil Energy	427	483	657
Special Foreign Currency	7	0	0
Subtotal	471	584	892
II. Financial Incentives Activities			
Alternative Fuels Demonstration Program	0	0	300
Grand Total	$ 471	$ 584	$1,192

CHART VII

REVISED FY 1978 ERDA BUDGET TO CONGRESS

PROGRAMMATIC EFFORT UNDER THE JURISDICTION OF THE SUBCOMMITTEE ON INTERIOR

	Budget Outlays ($ In Millions)		
	1976	1977	1978
I. Energy Research, Development & Demonstration			
Conservation	$ 19	$ 77	$ 174
Fossil Energy	242	445	531
Special Foreign Currency	0	2	2
Subtotal	261	524	707
II. Financial Incentives Activities			
Alternative Fuels Demonstration Program	0	0	3
Grand Total	$ 261	$ 524	$ 710

STATEMENT OF DR. PHILIP C. WHITE
ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FOR THE FY 1978 APPROPRIATIONS HEARINGS

The ERDA Fossil Energy Program rests on the basic premise that no matter which projection of future energy demand and supply is examined it must be concluded that (1) we must reduce demand for oil and gas; (2) increase the use of existing fuels other than oil and gas; and (3) begin to use new fuels. The Fossil Energy role is to increase supplies for all markets using liquids and gaseous fuels as well as for electric power. Our resources are coal, oil shale, and oil and gas formations which we either don't know how to extract or for which current extraction technologies are too expensive or which leave too much resource unused in the ground.

The near-term objectives (now to 1985) of the Fossil Energy Program include the production of additional oil and gas through enhanced recovery techniques, the development of processes for the direct combustion of coal for electric power generation and for industrial process heat, and low-Btu coal gasification for use by industry or by electric utilities. Since this latter technology is evolving from existing systems and can be applied in small sizes, it can be implemented in the near term.

Mid-term objectives (1985 to 2000) include the commercialization of developed technologies for coal liquefaction, high-Btu gas from coal and shale oil and gas production. In addition, the development of advanced electric power generation systems directly using coal, the development and operation of a commercial scale demonstration MHD power plant, and the commercial production of fuels and energy from coal in place (In Situ Coal Gasification) will be pursued.

Supporting these objectives are three essential activities. The first is the Material and Exploratory Research programs in the ERDA Energy Research Centers, National Laboratories, other Government agencies, private industry, and universities developing the basic and applied technology and data upon which present and future synthetic fuels processes depend. Another is the Demonstration Plants subprogram, the goal of which is to demonstrate on a cost-shared basis and at near-commercial scale, those selected second generation synthetic fuel conversion processes that have been developed and evaluated through industry and Government research and development. Finally, we must mention ERDA's proposed Alterhative Fuels

Demonstration Program effort. We intend to propose in FY 1978 specific project authorizations and appropriations for commercial demonstration plants which emphasize the use of existing technology. The commercial demonstration project requests will also identify the range of financial and possibly other incentives.

Fossil Energy projects are designed to incorporate appropriate environmental criteria. Environmental considerations, including health, safety, and socio-economics are incorporated into program planning. Environmental monitoring will be conducted at all plants and installations to insure compliance with applicable environmental regulations. Environmental impact statements and careful assessments will be prepared and issued covering proposed demonstrations. It is estimated that Fossil Energy will commit approximately $83.6 million for environmentally related efforts during FY 1978.

PROGRAM STRATEGY

The Fossil Energy Program strategy is derived from the research and development needs associated with the Coal, Petroleum and Natural Gas, and Oil Shale and In Situ Technology programs. Each of these programs requires different approaches and thus has a different strategy.

The Coal Program objectives are to develop and demonstrate, in cooperation with industry, the technology necessary for initiation of a synthetic fuel-from-coal industry as well as for improving methods of direct coal utilization. The strategy for implementing the Coal program is based on the assumption that the private sector will make widespread application of technologies demonstrated by ERDA. Thus, the program is keyed to producing concepts, processes, and equipment that meet the requirements of the private sector and will actually be used. This strategy is embodied in the cost-sharing philosophy used where sponsorship by industry is sought as evidence of substantial support for the ERDA program.

The objective of the Petroleum and Natural Gas Program is to increase the domestic production and reserves of oil and gas by accelerating the development and implementation of advanced techniques for extraction that are economically feasible, environmentally acceptable, safe, and socially acceptable. ERDA recently completed an in-depth quantitative analysis of the potential contributions from possible RD&D project areas that the Government could undertake in enhanced oil

recovery. This analysis resulted in priorities for the various project areas and a recommended 5-year program. A similar effort is underway for the Enhanced Gas Recovery Program.

The Oil Shale subprogram is oriented toward the development and demonstration of technology to recover energy in a safe and economically attractive manner from each of the major types of oil shale deposits. For environmental and other reasons, attention is being devoted primarily to modified in situ methods. This process which is a combination of mining and in situ processing represents an advanced state of technological demonstration and is expected to be a candidate for a commercial demonstration plant in the near future.

The In Situ Coal Gasification subprogram has the objective of developing environmentally acceptable technology for the commercial production of fuel and energy from coal in place. In situ processing, especially gasification, provides a means to utilize otherwise unusable resources while providing benefits of minimal environmental disruption, lower water usage and relief from mine safety problems and the shortage of skilled miners. If in situ processing can be controlled and run efficiently, the savings from a smaller scale plant could permit a selling price for the gas which would be cheaper than entirely surface-based gasification processes.

The appropriations and activities for coal, oil, gas and oil shale differ because of the unequal levels of private industry R&D investment. The state of development of conversion and extraction technologies varies considerably. The FY 1978 budget for Fossil Energy is $656.9 million (BA) and, of this total, coal received 82.0 percent, petroleum and natural gas 11.7 percent, while oil shale and in situ technology received 6.3 percent. The FY 1978 budget request we will present today includes an amendment to the previous estimates transmitted to Congress. The amendment would provide an additional $5.0 million in the Enhanced Gas Recovery Subprogram to accelerate the Eastern Gas Shales Project (Devonian Shale) and $12.0 million in the Demonstration Plants Subprogram to initiate the design of a Solvent Refined Coal Demonstration Plant.

CURRENT ORGANIZATION

The additional operating experience of Fossil Energy and ERDA has led to the realignment of certain functions in early FY 1977. This realignment transferred part of the functions of the Office of Commercialization and the program management responsibilities for the Energy Research Centers to Fossil Energy. The new organization, as shown in Figure 1, consists of an Assistant Administrator for Fossil Energy, two Deputy Assistant Administrators and seven line divisions: Coal Conversion and Utilization, Oil, Gas and Shale Technology, Materials and Exploratory Research, Magnetohydrodynamics, Major Facility Project Management, Commercial Applications and Environmental

ERDA FOSSIL ENERGY ORGANIZATION

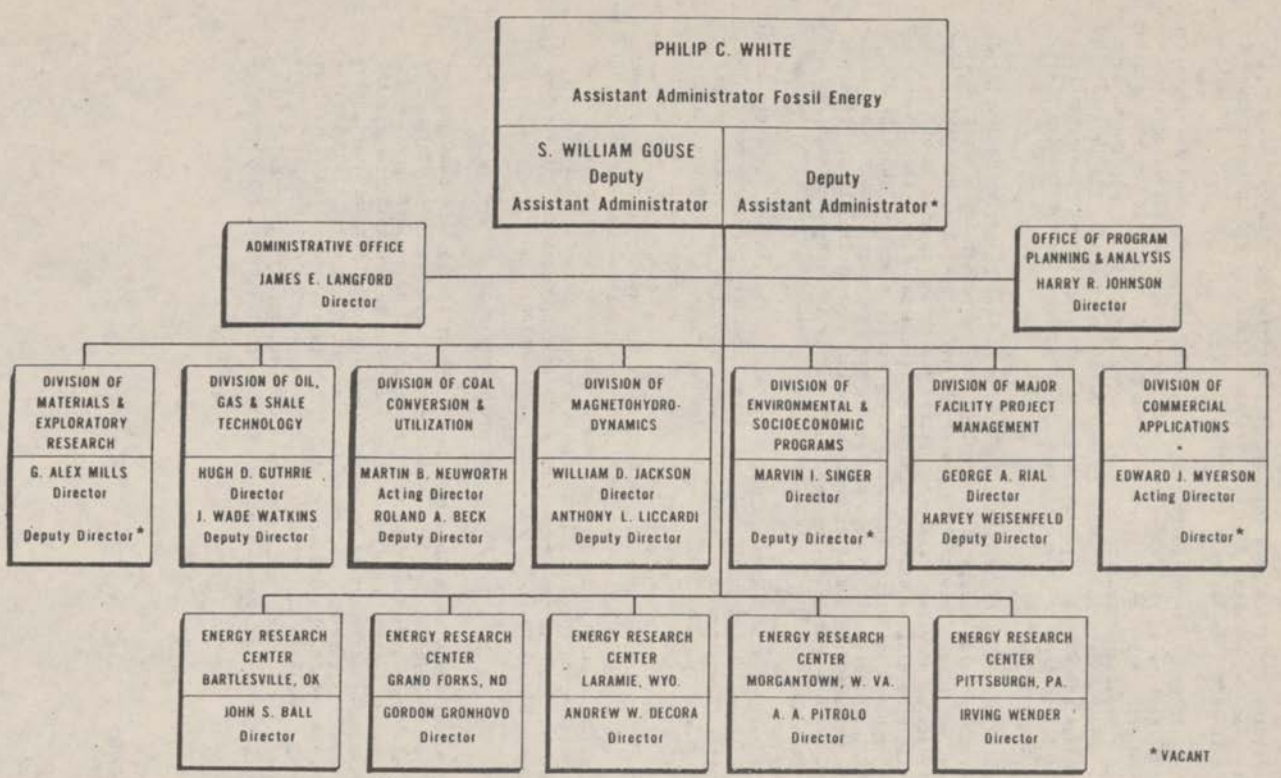


Figure 1

and Socioeconomic Programs. The Five Energy Research Centers are located at Bartlesville, Oklahoma; Grand Forks, North Dakota; Laramie, Wyoming; Morgantown, West Virginia; and Pittsburgh, Pennsylvania. Staff offices include the Office of Program Planning and Analysis and an Administrative Office. A small Senior Staff has been designated to provide special assistance, advice and counsel and program planning and management.

PROGRAM ACCOMPLISHMENTS

Major accomplishments during FY 1977 in the coal conversion and utilization effort will include the start-up of BIGAS, Synthane and Steam Iron Pilot Plants; the completion of the Synthoil PDU at Bruceton, Pennsylvania; the initiation of construction of the H-Coal Pilot Plant and the operation of the 30 MW Atmospheric Fluidized-bed Boiler PDU.

The Materials and Exploratory Research efforts during FY 1977 anticipate continuing the significant progress in determining reliable materials and valves for coal conversion plants. In addition, we expect to complete process research on a novel, cheaper catalytic coal gasification process, and another for making gasoline from coal, and initiate a starter grant program to stimulate fossil energy research at universities.

The MHD program started construction of the Component Development and Integration Facility (CDIF) building and initiated the first CDIF generator channel. Other significant accomplishments include the delivery of superconducting magnet for the Soviet U-25 Facility as well as a superconducting magnet for the CDIF.

The Demonstration Plants subprogram initiated conceptual designs for a High-Btu Synthetic Pipeline Gas Demonstration Plant, an Industrial Low-Btu Fuel Gas Demonstration Plant, two Small Industrial Low-Btu Fuel Gas Demonstration Plants, and a Direct Combustion Demonstration Plant. We also re-evaluated the Clean Boiler Fuel program and plans call for a clean boiler fuel test bed module to be initiated for evaluation of the process before making a final decision on proceeding with the larger scale demonstration plant.

We implemented an improved management plan for Enhanced Oil Recovery and initiated cost-shared field tests. We also completed a project plan for characterization and stimulation of Eastern gas shale (Devonian Shale) and began a plan for characterization and stimulation of Western tight gas sands.

In the oil shale program we are negotiating cost sharing contracts for several in situ retorting experiments, completed a direct combustion shale-oil production test at Rock Springs, Wyoming, and started a Michigan Antrim Shale gasification project with industry, universities and state agencies. In the in situ coal gasification area, we completed a linked vertical-well process test, started a field gasification test on the packed-bed process, and started fielding a first combustion test on directional wells (longwall generator process).

THE COAL PROGRAM

Coal is the Nation's most plentiful fuel resource with an estimated reserve sufficient to last several centuries. The Coal Program efforts are aimed at tapping this abundant source of energy for direct use as a fuel in an efficient and environmentally acceptable manner or for processing into synthetic fuels needed to do many of the chores previously done by oil and natural gas. The principal objectives of the Coal Program are to accelerate the development of environmentally acceptable technology for converting coal to liquid and gaseous fuels; to stimulate improved methods for the direct combustion of coal; to foster the rapid development of advanced power conversion systems, including magnetohydrodynamics for generating electricity from coal; to validate the technical, economic, and environmental acceptability of second-generation coal processes by designing, building, and operating near-commercial scale modules; to foster through the use of a variety of incentives the construction and operation of a limited number of commercial demonstration plants using coal; and to expand the technological base and the supply of technically trained manpower to support the evolving conversion and utilization technologies.

To achieve the goal of increased coal utilization, we request FY 1978 operating expenses of $447.5 million and plant and capital equipment of $91.2 million. The FY 1978 request is an increase of $129.7 million over the FY 1977 level. The most significant increases occur in the Liquefaction Subprogram ($34 million directed at several pilot plant projects) and the Low-Btu Gasification subprograms $40.8 million directed at the construction of major test facilities). I would like to briefly describe the objectives of each of the subprograms which constitute the Coal program, list the major ongoing projects and describe how the requested appropriation will be used.

LIQUEFACTION

The products derived from coal liquefaction processes could compete with petroleum refined products in two distinct markets. One market uses low-ash, low-sulfur boiler fuels suitable for clean electric power generation and industrial steam generation. The other market uses high-grade fuels such as gasoline, heating oil, and chemical feedstock. The strategy of the Liquefaction subprogram is to support a number of liquefaction processes in parallel from laboratory scale, through process development unit (PDU), to pilot plant stage. This approach is based on a number of considerations. The variety of coals to be processed, coupled with the requirement for a wide range of fuels, will necessitate commercialization of a number of liquefaction processes.

Projects are supported in four liquefaction areas: solvent extraction, direct hydrogenation, pyrolysis, and indirect liquefaction. It is highly unlikely that any single second-generation process will be used exclusively. Processes may be selected depending on the coal type, the products sought, and the plant site selected. An appropriate program is being planned involving production of sufficient quantities of representative type of coal derived fuels to establish that these fuels are interchangeable in the marketplace with their petroleum counterparts.

Significant efforts under this subprogram include the following:

- Direct Hydrogenation. Construction of the H-Coal pilot plant is currently in progress. Operations of the Synthoil PDU will be initiated in FY 1978.

- Solvent Extraction. The SRC pilot plant is currently operating. Detailed design for the Donor Solvent Pilot Plant will be started in FY 1978.

- Pyrolysis. PDU's on the Clean Coke and entrained bed pyrolysis processes are in operation.

- Indirect Liquefaction. Modifications to indirect liquefaction processes are being expanded at laboratory scale.

The budget request for FY 1978 of $107.4 million in budget authority is an increase of $34.4 million over the FY 1977 level. The major

areas of increase are for the construction of a Donor Solvent Liquefaction pilot plant and increased costs for construction of the H-Coal pilot plant. In addition, FY 1978 will be the first full year of a new operating contract for the Cresap Test Facility.

A summary of the major projects and requested FY 1978 funding is shown in Figure 2.

FIGURE 2
Liquefaction

Project & Location	Product Description	1978 Funding (000)	Status
H-Coal Pilot Plant Cattletsburg, Ky.	Syncrude & Boiler Fuel	$26,000	Complete Construction
Synthoil PDU-PERC, Bruceton, Pa.	Boiler Fuel	11,000	Initial operations
SRC Pilot Plant Tacoma, Washington	Solid Fuel	15,000	Operation for data base
Donor Solvent Pilot Plant, Baytown, Texas	Syncrude	30,300	Detailed Design
Cresap Facility Cresap, W. Va.	Equipment tests (Boiler Fuel)	12,500	Operations
Coalcon Test Bed (Site to be determined)	Clean Boiler Fuel	*	Process Evaluation

* Proposed FY 1977 reprogramming action for $10,000,000 resulting from reappraisal of Demonstration Plant effort.

HIGH-BTU GASIFICATION

The major objectives of the high-Btu gasification subprogram are to develop, in cooperation with industry, new and improved second generation gasification technology necessary for the construction of commercial scale plants for processes that convert coal to substitute natural gas (SNG) of pipeline quality. This subprogram includes a number of projects for development of an improved process to manufacture SNG. Although many gasification processes under development

are similar in objective each is characterized by important differences that warrant concurrent development. These differences include ability to handle different types and sizes of coal, reaction conditions, pretreatment, method of feed, reactor configuration, heat supply, gas purification, and methanation process.

As a result of the Government's efforts in combination with the work being performed in the Joint ERDA/AGA program, five pilot plants representing the further development of five different processes for the gasification of coal, an auxiliary process for the generation of electricity, have been initiated. The HYGAS and Carbon Dioxide Acceptor Pilot Plants are constructed and have been operated over periods of time long enough to demonstrate that each process is technically feasible. The construction of two other pilot plants and one PDU for the continued development of Synthane, BIGAS, and Self-Agglomerating Ash gasification processes were completed in FY 1976. The construction of the Steam-Iron Pilot Plant was also completed in FY 1976.

Although the development of work on two pilot plant projects will be completed prior to FY 1978, the budget request for FY 1978 is $7,346,000 greater than FY 1977. This increase can be attributed to a continuing escalation in costs required to operate the remaining plants, the development of a new gasification concept, catalytic gasification at the pilot plant level, continuation in the development of the Hydrane process, and expansion of work in key support projects.

A summary of the projects and FY 1978 funding requested is shown in Figure 3.

FIGURE 3
High-Btu Gasification

Project & Location	Product Description	1978 Funding (000)	Status
HYGAS Chicago, Ill.	High-Pressure Multi-state Hydro-gasification	0	Operational
BI-GAS Homer City, Pa.	High-Pressure Entrained Flow, Multi-stage	11,000	Operational
Synthane Bruceton, Pa.	Mid-Pressure Fluidized Bed, Single Stage	14,500	Operational
Steam-Iron Chicago, Ill.	Hydrogen Generator	5,700	Operational
Hydrane	Single Stage Non-Catalytic Hydro-gasification	3,500	Feasibility Design
Catalytic Gasification Pilot Plant	Catalytic Gasification	3,500	Feasibility Design

LOW-BTU GASIFICATION

The potential market for clean burning low-Btu gas as a fuel for electric utilities and industrial users as a chemical feedstock has increased as a result of the energy crisis, the decrease in natural gas reserves, and more stringent environmental regulations. The generation of low-Btu gas from coal requires a less complex plant than required for the production of high-Btu gas. As a result, for an equivalent energy output from each type of plant, capital and operating costs are lower for an equivalent Btu.

The primary activity of this subprogram is the economical integration of low-Btu gasifiers, gas cleanup systems, and end-use systems. To achieve this result for power generation, construction of the Powerton combined-cycle test facility at Pekin, Illinois, will begin in FY 1977. For industrial use of low-Btu gas, Program Opportunity Notices (PONS)

were released for Gasifier in Industry and Hydrogen-from-Coal projects. The Gasifier in Industry project involves the use of low-Btu gas in one or more industrial processes, or as a fuel for steam boilers, unit heaters, and industrial dryers. Six proposals received for this project were selected for negotiation, covering a variety of industries and institutional users. Concurrently, promising new concepts for improved gasification techniques are being actively researched at the PDU and pilot plant level. These include fixed-bed, entrained-bed, fluidized-bed, and molten salt systems. Improved gas cleanup methods that will operate at elevated temperature and pressure are under development.

A summary of the major projects and requested FY 1978 funding is shown in Figure 4.

FIGURE 4
Low-Btu Gasification

Project & Location	Description	1978 Funding (000)	Status
Fixed-Bed Gasification MERC, Morgantown, W. Va. Grand Forks, North Dakota;	Stirred Slagging	4,550	Operational
Fluidized-bed Gasification	Two stage three stage	5,000	Operational
Powerton Combined-Cycle Test Facility Pekin, Illinois	Gasifier (LURGI) with Gas Turbine Modifier for Low-Btu Gas	28,000	Design
Hydrogen from Coal Facility	TBD	18,000	Procurement Stage
Gasifiers in Industry (six awards)	Industrial/ Commercial/ Institutional Applications	10,000	Contract Negotiations

The major areas of increase for FY 1978 include the Powerton Combined-Cycle Test Facility, Hydrogen from Coal project, and Gasifiers in Industry efforts.

ADVANCED POWER SYSTEMS

The Advanced Power Systems subprogram is aimed toward the development of advanced power conversion systems which will permit, in an environmentally acceptable manner, increased use of coal for power generation using both direct coal-fired systems and coal-derived fuels fired systems. Over the past 15 years the conversion of coal-burning steam electric power plants to burn oil has been so great that current power generation from coal has been reduced by about 50 percent. Increased use of coal to produce electric power can relieve dependence on oil and natural gas for that purpose, thus releasing these fuels for other uses.

The major potential economic advantages offered by advanced power systems result from the fact that high-performance combined-cycle turbine systems are expected to have lower capital cost and higher coal to electricity power generation efficiency than systems burning coal and generating electricity from high pressure steam. Additional benefits from the use of advanced power generation systems include reduced water requirements and reduced fuel requirements of potentially high-efficiency generation equipment. The program goal is to establish a technical base for use in developing advanced power systems.

Projects initiated in FY 1976 using the open-cycle gas turbine as the topping portion of combined cycles are continuing. Efforts in blade and vane cooling, ceramic component evaluation, and materials corrosion and reliability studies are underway. In the closed-cycle power system area, work has proceeded on the high-temperature heater or boiler, on materials evaluation, and on system studies to evaluate overall power generating costs.

A summary of the major projects and requested FY 1978 funding is shown in Figure 5.

FIGURE 5
Advanced Power Systems

Project & Major Contractors	Description	1978 Funding (000)	Status
Open Cycle Gas Turbine Westinghouse General Electric United Technology Curtiss Wright	High Temp. Turbine Technology, Plant Design, Blade Cooling, Ceramic Technology and Test Combustor Design	18,700	Phase I complete Phase II in progress

The major areas of increase include efforts associated with Phase I and II of the Open Cycle Gas Turbine such as improved cooling, blade and vane research, bearings and seals selection, and combustor development.

DIRECT COMBUSTION

The primary objectives of the Direct Combustion subprogram are: (1) to develop fluidized-bed combustion systems capable of directly burning high-sulfur coals of all ranks and quality in an environmentally acceptable manner, (2) to develop technology to substitute coal for a substantial portion of oil in combustors capable of firing coal-oil mixtures, and (3) to improve reliability and efficiency of present boilers. To enable coal resources to be fully exploited, research efforts are being directed toward development of environmentally acceptable methods of combustion. To achieve this, the total effort has been integrated in terms of both broad technical approach and special technical components. Specific areas of research include fluidized-bed combustion; combustion and heat transfer characteristics of chars, coal-oil slurries, solvent-refined coal, and coal-derived liquid fuels when burned in conventional furnaces; causes of adherent slag and ash deposits and identification and control of toxic elements emitted during the direct combustion of coal.

Significant accomplishments have been made under this subprogram. The 30 MW atmospheric fluidized-bed boiler project, located at the Monongahela Power Company plant at Rivesville, West Virginia, began

initial operation. Architect-engineer contractors were selected for the Atmospheric and Pressurized Component Test and Integration Units. In the Industrial Applications effort, eight contractors have been selected to design the systems that are to be built in industrial and institutional facilities. The pressurized fluidized-bed efforts include the design of a combined cycle pilot plant of approximately 13 MW capacity. Multiple contracts have been awarded to modify or retrofit, operate and test existing boilers, heaters and furnaces, and to design, operate, and test a prototype coal-oil slurry mix distribution system.

A summary of the major projects and requested FY 1978 funding is shown in Figure 6.

FIGURE 6
Direct Combustion

Project & Location	Description	1978 Funding (000)	Status
Fluidized-Bed Boiler, 30 MW Rivesville, West Virginia	Multicell-Fluidized Bed Boiler	4,000	Shakedown
Component Test and Integration Unit (Atmospheric) MERC, Morgantown, West Va.	Test Unit Fluidized/Bed Combustor/Boiler	5,500	Design
Fluidized-bed combined cycle Pilot Plant Wood Ridge, N. J.	Gas Turbine-Steam Turbine Combined Cycle	7,000	Technical Evaluation Design
Component Test and Integration Unit (Pressurized) Argonne National Lab	Pressurized Fluidized-bed Combustor Boiler Test Unit	4,729	Design Stage
Industrial Applications (Eight awards)	Industrial, Institutional and Commercial Applications	10,000	Awards in Process, Design Started
Coal-Oil Slurries	Utility, Industrial and Blast Furnace	7,000	Award in Progress, Designs Started

The FY 1978 request will support testing and modification of the 30 MW multicell boiler and provide data for design of a demonstration plant. Fabrication of several prototype systems in the industrial and institutional fluidized-bed combustion application program will continue. In FY 1978, combustion activities will be well underway for both the atmospheric and pressurized component test and integration facilities. In addition, the construction of the pressurized fluidized-bed combined cycle pilot plant will begin in 1978. Data will be obtained on the operation of the units converted to burn coal-oil mixtures in FY 1978, and this data made available to industry for prompt implementation.

ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY

The Advanced Research and Supporting Technology subprogram serves as the central exploratory research arm and systems studies activities for all program areas of Fossil Energy. The major objectives of this subprogram are: (1) to develop innovative fossil energy technology leading to significantly cheaper synthetic fuel processes, (2) improve the operational reliability and efficiency of synthetic fuels plants through research on more corrosion/erosion resistant materials and components, (3) develop advanced techniques to permit increased combustion of coal in an environmentally acceptable manner, (4) help assure an adequate supply of technically trained personnel from the Nation's university system, and (5) conduct analyses of processes, technologies and systems, and to formulate planning and policy options for management decision-making.

During FY 1977 significant accomplishments include the development of a significantly lower cost, environmentally acceptable process to make gasoline from coal; process research on a novel cheaper catalytic coal gasification process; progress in determining more reliable materials and valves for coal conversion plants; and development of an improved, integrated planning systems. The FY 1978 request will permit new emphasis on exploratory research to potentially reduce the cost of producing synthetic fuels from coal as well as complete lab development of promising processes for scale-up of selected technologies.

Major ongoing projects are shown in Figure 7.

89-805 O - 77 - 3

FIGURE 7
Advanced Research and Supporting Technology

Research Area/Major Projects	Total Contract Value (Millions)	Number of Contractors
More Economical Synfuels Processes Methanol-to-Gasoline (Mobil) Catalytic Gasification (Exxon) Hydropyrolysis (Gulf, IGT, Sun BNL)	55.4	107
Reliable Materials and Components Coal Gasification (MPC, ANL, ORNL, NBS)		
Fireside Corrosion (Combustion Eng., Battelle, Exxon, G.E., Westinghouse)	14.6	29
Valves for Coal Gasification (Consol, Controls, Fairchild, MERC)	7.6	7
Improve Direct Utilization of Coal Benefication (SRC, PERC, Ames) Combustion Processes (MRI, GFERC, MERC)	5.8	34
Exploratory Research at Universities	24.5[1/]	77[1/]

1/ Included in above.

DEMONSTRATION PLANTS

The objectives of the Demonstration Plants subprogram is to demonstrate at or near commercial scale those promising environmentally acceptable coal and oil shale processes which have either been developed and evaluated through industry or Government research and development. This subprograms objectives will be achieved through the successful construction and operation of a number of demonstration plants. Economic, technological, and environmental criteria have been used to evaluate candidates for fossil fuels demonstration. Four plants have been authorized to date in the following technologies: clean boiler fuels, pipeline gas, fuel gas, and direct combustion. For FY 1978 we are requesting authorization to add two low-Btu fuel gas small industrial plants and a Solvent Refined Coal (SRC) demonstration plant.

The subprogram strategy is based on achieving objectives via the commercial sector. The strategy encourages industry to initiate and direct demonstration of processes by providing Government funding for studies and conceptual plant design while sharing the cost (nominally on a 50/50 basis) with industry during the detailed design, construction and operation of the demonstration plant.

The Demonstration Plants subprogram is the final step in the R&D process aimed at reducing the risk and accelerating industrial process implementation. The FY 1978 Operating Expenses request provides for the design for direct combustion, SRC, and low-Btu fuel gas small industrial demonstration plants; planning for other candidate projects, equipment development and component testing; and engineering, environmental and socio-economic, and planning support activities.

Figure 8 displays the major projects included in this subprogram.

FIGURE 8
Demonstration Plants
Plant and Capital Equipment

Major Projects	Total Estimated Cost	FY 1978 Request (Millions)	Status
Clean Boiler Fuel (New Athens, ILL.)	*	0	*
High-Btu Synthetic Pipeline Gas (site undetermined)	220.0	29.0	Under negotiation
Low-Btu Fuel Gas (site undetermined)	150.0	36.0	Under negotiation
Low-Btu Fuel Gas, small industrial (2 plants) (site undetermined)	52.0**	5.0	Planned conceptual design
Fluidized-Bed direct combustion (site undetermined)	162.0**	2,0	Planned conceptual design
Solvent Refined Coal (site undetermined)	***	2.0	Planned conceptual design

* Project being re-evaluated
** Very preliminary estimates of Federal share.
*** Very preliminary estimate of the Federal share is 400-600 million dollars.

MAGNETOHYDRODYNAMICS (MHD)

The major objective of the MHD subprogram is to achieve successful operation by the late 1980's of a commercial scale facility to generate electricity from coal or a coal derived fuel, using MHD generation principles. The MHD process of electrical power generation is a means of utilizing our vast coal reserves in a highly efficient and environmentally attractive manner. The MHD program is structured to accomplish the successful operation of a commercial demonstration plant incorporating the MHD process--but, as an advanced technology, it is necessary to address the major problems initially while comparing alternative components and designs through parallel development.

The strategy of the program is to progress through three overlapping phases, each focused on specific development requirements for commercial demonstration. The purpose of Phase I is to develop and integrate alternative MHD core components at a scale of approximately 50 thermal megawatts and to combine these with such other components of an MHD plant as are needed to develop engineering data and experience for pilot scale facilities. Phase II will provide engineering demonstration by system testing of selected complete test trains at approximately 250 thermal megawatts and up to commercial operating durations (1,000 to 2,000 hours). Phase III will provide the capability to demonstrate commercial feasibility at approximately 1,000 megawatts and related operating parameters.

The major focus for the first phase is the Component Development and Integration Facility (CDIF), for which ground was broken on May 16, 1976. Construction of this facility is expected to be completed in 1978. It is this facility where operational test conditions will be achieved and where various MHD components will be tested and integrated along with other components of the MHD system for which pre-pilot scale data are required. The CDIF, at a 50 megawatt thermal scale, represents the minimum size that can exhibit the critical phenomena and interactions between the various components and which can provide for subsequent scale-up to the ETF. The interrelation of these components is complex and requires simultaneous development of alternative engineering approaches and their testing in a single facility (CDIF). The examination of critical phenomena associated with their operations will enable a design basis to be selected for the ETF. The testing of these components and subsystems to be performed in the CDIF will start in 1978. In the meantime, we are making progress. Laboratory tests and simulation studies, including data from international cooperation, are providing engineering experience and design data for prototype component fabrication.

The FY 1978 budget authority request for Operating Expense is $45,800,000 an increase of $10,810,000 over the FY 1977 level, primarily to continue the component development effort for CDIF hardware test. In addition, $4,200,000 is requested under the Plant and Capital Equipment appropriation for the Component Development and Integration Facility. Construction of the Component Development Integration Facility (CDIF) began in FY 1976 and will be completed in 1978. The facility is located in Butte, Montana, and covers about 50 acres of a 93-acre site. It consists of two test beds each capable of testing and evaluating MHD components of about 50 thermal megawatt size. The FY 1978 budget request will provide for the installation of equipment into this facility.

Figure 9 shows the major projects included under this subprogram.

FIGURE 9
Magnetohydrodynamics

	Major Project	FY 1978 Funding (000)	Major Contractors	Status
I.	Componenet Development and Integration Facility (CDIF)	$ 4,200		Title I completed Oct. 1976. Title II initiated.
A.	Capital Construction			Completed Feb. 1977.
1.	Architect Engineering		R.M. Parsons	Long lead procurement
2.	Site Development		Taylor-Donnell	initiated.
3.	Major Construction		Kaiser	
B.	Initial Test Train Experimental Hardware	12,012		Process calculations complete. Detail
1.	Combustor		Pittsburgh Energy Res. Center	combustor design initiated Engineering tests in progress. Design specs.
2.	Generator		AVCO	prepared. Procurement
3.	Magnet		TBD	initiated. System
4.	Integration		Westinghouse	integration initiated.
C.	Facility Start-up & Checkout	5,820	Montana Energy Institute	Familiarization, procedures, and environmental monitoring underway.
D.	Advanced Test Train Experimental Hardware	5,523	TBD	Design specifications in preparation.
II.	Engineering Test Facility (ETF)	600	AVCO General Electric Westinghouse	Conceptual design initiated. Preliminary site and environmental studies underway.

PETROLEUM AND NATURAL GAS PROGRAM

The objective of the Petroleum and Natural Gas Program is to increase the domestic production and reserves of oil and gas, including heavy oil deposits and tar sands, from both onshore and offshore areas. This is to be accomplished by accelerating the development and implementation of advanced techniques for exploration and extraction that are economically feasible, environmentally sound, operationally safe, and socially acceptable.

The strategy for implementing the program is to encourage and support industry efforts to develop and demonstrate petroleum and natural gas technology to increase production rates and yields from existing and future hydrocarbon reservoirs by:

- Determining critical technology needs.
- Identifying and prioritizing needed R&D efforts and determining the appropriate Government role.
- Establishing and implementing cost-shared development and demonstration projects.
- Maintaining an aggressive research program.
- Providing for the documentation and dissemination of data.

The FY 1978 request of $76.7 million represents an increase of $33.5 million over FY 1977. The increases are for the Enhanced Oil Recovery subprogram ($22.5 million) and Enhanced Gas Recovery ($12.4 million). I would like to briefly describe the subprograms which constitute this important program.

ENHANCED OIL RECOVERY

The objectives of the Enhanced Oil Recovery (EOR) subprogram are to encourage and support industry participation in developing and demonstrating technologies to enhance the production rate and recovery of oil in place. Present extractive technology is grossly inefficient. Two-thirds of the oil discovered to date remains in the reservoirs and cannot be recovered with current practices and economics. The potential for EOR is in the area of 60 billion barrels of normal gravity oils and 28 billion barrels of heavy oils and bitumen. This

potential constitutes the goal for EOR which could extend the supply of domestically available resources by at least 10 critical years.

ERDA has initiated 23 cost-sharing field contracts with industry that will test the feasibility of four EOR technologies in various types of domestic reservoirs. The funding for these projects is roughly 35% ERDA and 65 percent industry. Based on the estimates of industry activity the ERDA cost-shared contracts represent about one-third of the industry EOR projects in these four categories. In micellar-polymer flood tests, for example, well over half the acreage under test is in projects sponsored by ERDA. Some of the 23 field tests underway in FY 1977 can already be credited with small additional oil production although the production response is normally delayed by approximately 1 year and most of the incremental production comes later in a project's lifetime. While it is too early to judge the results of the tests, all the projects have already generated higher quality geological and engineering data which are indispensable in designs of successful projects like these.

The need for improved oil recovery techniques have been recognized in the recently completed in-depth strategic, analysis of enhanced oil recovery. This comprehensive study contained in the "Management Plan for Enhanced Oil Recovery" brought together available information in a logical documented framework of analysis. Based on current and projected industry EOR efforts a 600,000 barrel per day incremental production increase from EOR has been estimated by 1985. If the budget request of $46.4 million for FY 1978 is appropriated and the projects begun are continued as programmed, the estimated incremental daily production in 1985 could be about 800,000 barrels per day.

The major projects included under this subprogram are shown in Figure 10.

FIGURE 10
Enhanced Oil Recovery

Technology	Number of Contracts	Contract * Value (Millions)
Micellar-Polymer	6	$ 77.1
Carbon Dioxide	3	7.2
Improved Water Flooding	3	25.4
Thermal	7	37.0

* The range of industry cost sharing (%) for individual projects is 12 percent to 77 percent. The average is 65 percent.

ENHANCED GAS RECOVERY

Natural gas currently supplies approximately 30 percent of the total domestic energy use. Current proved natural gas reserves amount to approximately an 11 year supply at the current consumption rate. The bulk of these proved reserves are found in conventional reservoirs which are generally located in the Gulf Coast and Southwest regions of the United States. These reserves have been developed because they can be easily produced, have high recovery efficiencies and provide acceptable profit incentives.

There are four large unconventional gas resources that are not being fully exploited.

- The gas-bearing Devonian shales of the Eastern United States.
- The low-permeability (tight) gas sandstones of the Rocky Mountain region.
- The free methane (natural gas) present within coal seams.
- The high pressure, methane-saturated saltwater aquifers of the Gulf Coast region (geopressured aquifers).

Specific near-term objectives of the Enhanced Gas Recovery (EGR) subprogram are: (1) improvement of techniques necessary for prompt, orderly development of the natural gas resources, (2) addition of 10 trillion cubic feet of producible reserves by 1985, and (3) increase gas production by an incremental 3 billion cubic feet by 1985.

Accomplishments to date primarily have been in developing an understanding of problems associated with resource characterization and evaluation of target sources and with stimulation technology development. Initial efforts include the following:

Eastern Gas Shales Project planning is essentially complete and 14 contracts have been issued.

Eight cost-shared field tests with industry in massive hydraulic fracturing were initiated.

A new directionally drilled well cost-shared project has begun.

Three new chemical, explosive fracturing cost-sharing projects have been negotiated.

A comprehensive EGR Program Strategy Document, which will coordinate planning and implementation of ERDA's EGR activities will be developed this year.

The FY 1978 budget request of $27.3 million is an increase of $12.4 million over FY 1977. The budget request will ensure continuation of the Eastern Gas Shales Project (Devonian shale) at the level of $15.0 million. The request also provides for a balanced program for the development of high priority projects addressing the considerable potential resources of the tight sandstone formations of the Western United States.

The Eastern Gas Shales Project is emphasized because it offers a substantial pay-off in the relative near-term. Preliminary information suggests that as much as .7 Quad of gas can be obtained by 1985 from the shallow formations of the Devonian Age shales. Therefore, the resource can be reached at a relatively low cost and the production would be close to large residential and industrial markets.

Figure 11 displays the major activities conducted under this subprogram.

FIGURE 11
Enhanced Gas Recovery

Technology	Number of Contracts	Contract* Value (Millions)
Massive Hydraulic Fracturing	11	$ 34.9
Chemical Explosive Fracturing	5	5.5
Deviated Well Fracturing	2	1.2
Resource Evaluation	18	11.6

* Range of industry cost sharing (%) for individual projedts, 0 to 78 percent; average 55 percent.

In addition to the subprograms discussed above, the Petroleum and Natural Gas Program includes the Drilling, Exploration and Offshore Technology subprogram and the Processing and Utilization subprogram. These important supporting efforts are essential elements in furthering the basic objectives of the Program.

OIL SHALE AND IN SITU COAL GASIFICATION PROGRAM

The objectives of this program are as follows:

- To develop oil shale technology capable of improving total resource recovery and to lower environmental impact and water requirements.

- To develop environmentally acceptable technology for the commercial production of fuels and energy from coal in place.

Coal and oil shale are the Nation's two most abundant energy resources. However, most of the coal and oil shale resources are located in deposits that are unsuitable for commercial exploitation by conventional mining and surface handling techniques. The strategy of the Oil Shale and In Situ Coal Gasification Program is to develop various extraction techniques capable of producing liquid and gaseous fuels as well as energy in an efficient and environmentally acceptable manner from coal and oil shale deposits that, for technical and economic reasons, are currently unmineable.

The FY 1977 appropriation for the Program was $31.0 million; for FY 1978 the request is $41.5 million, representing an increase pf $10.5 million. The request for FY 1978 includes $39.0 million for Operating Expenses and $2.5 million for Capital Equipment. The proposed funding increase will be used to accelerate the development and eventual commercialization of in situ coal and oil shale technologies to enhance the Nation's future usable energy resources. I would like to briefly describe the objectives of the subprogram which make up this Program, list the major ongoing projects, and describe how the requested appropriations will be used.

OIL SHALE

The near-term objective of the Oil Shale subprogram is to support development of a commercial shale oil and gas industry with a daily capacity equivalent target of approximately 300,000 barrels per day by 1985. This objective will be fostered by providing the technology base for commercial implementation by 1980 through development and demonstration projects in cooperation with industry. The midterm objective is to provide the technology base to expand an oil shale industry to its full potential by maximizing resource recovery efficiency and minimizing environmental impacts and water requirements through cooperative projects.

The program consists of shale oil production, shale gas production, environmental and supporting research. The major emphasis of the subprogram is on shale oil production and this budget category accounts for aproximately $21 million of the $28 million of operating expense requested in FY 1978 for the entire subprogram.

A major thrust of ERDA's shale oil production effort is the development of in situ technologies resulting from a Program Opportunity Notice (PON) issued in FY 1976. Of the five different potential in situ process categories addressed by the PON, projects representing four of these were selected for contract negotiations. Of the various processes being developed, no one process is applicable to all major resource types. Each process was selected because it appears applicable to a particular type of resource.

ERDA's in-house oil shale research, performed by the Laramie Energy Research Center and by some of ERDA's National Laboratories, is aimed at better understanding of process parameters needed to control underground oil shale processing. This research includes field experiments in western oil shale, closely coordinated with laboratory research, to provide data for larger scale projects expected to be performed by industry.

An initial contract to perform in situ research to obtain gas from eastern oil shales of Devonian and Mississippian age has been signed with Dow Chemical Company.

Environmental issues that are unique to in situ oil shale processing are addressed as integral parts of all field work conducted either in house by ERDA or by industry contractors.

A small but important component of ERDA's program is supporting research. This includes oil shale characterization work and shale oil refining studies. It also includes environmental monitoring of surface retorting performed by industrial lessees of the Anvil Points Facility in Colorado.

The FY 1978 operating expense budget authority request is $28,000,000, an increase of $5,722,000 over the FY 1977 level. The increases requested are to provide for continuation of shale oil production projects underway in FY 1977 ($4,855,000); provide an added $250,000 for shale gas production, increase environmental studies by $212,000; and increase essential supporting research by $405,000. In addition, an increase of $450,000 for capital equipment will support several projects.

In addition to the oil shale efforts outlined above, ERDA will propose to Congress specific projects and project related authorizations and appropriations for selected commercial demonstration plants. A shale oil demonstration plant is considered one of the high priority projects to utilize a financial incentive arrangement under the alternative fuel demonstration program.

The major projects included under the Oil Shale subprogram are shown in Figure 12.

FIGURE 12
Oil Shale

Major Projects	Contract Value (millions)	Performer	Location
Shale Oil Production	16.2	ERC's, National Labs, Contractors, Universities	Various
Gas Production	0.45 3.15	LERC Contractors	Laramie, Wyo.
Environmental Control Technology	0.02 0.47	LBL Universities	Berkeley, Cal.
Supporting	1.25 0.66	LERC Universities	Laramie, Wyo.

IN SITU COAL GASIFICATION

The In Situ Coal Gasification Subprogram seeks to enhance the utilization of the vast coal reserves of the United States that may supply much of our midterm energy needs. More than 85 percent of our coal resources are unsuitable for commercial exploitation by conventional mining. In situ processing, especially gasification, provides a means to utilize these otherwise unusable resources while providing benefits of minimal environmental disruption, lower water usage, relief of mine safety problems, and the shortage of skilled miners.

The nature of the coal resource varies from region to region in thickness, depth, dip, and composition. The present subprogram efforts include projects that use different technical approaches

to exploit different resources. Proof of commercial feasibility will require both scale-up of process size and verification of design performance at a number of sites. Process development is pursued by field tests and supported by laboratory research and analytical studies directed toward understanding and controlling process behavior. Remote instrumentation will be developed to ensure adequate process monitoring and control. Environmental studies support each project to ensure that impacts will be minimized.

The Linked Vertical Wells process is being developed by the Laramie Energy Research Center (LERC). The Hanna 1 test at a site near Hanna, Wyoming, gave 6 months production of 126 Btu/SCF gas. The gas quality was maintained over a 2 month test period ending in August 1976.

The Packed Bed process is being developed by the Lawrence Livermore Laboratory (LLL) using a site at Hoe Creek, near Gillette, in the Powder River Basin, Wyoming. The first field test of the process concept was initiated in FY 1976. A preliminary gasification with air was run at the start of FY 1977 to scope potential process problems. Larger scale tests will be fielded starting in mid FY 1977.

The Longwall Generator process is being developed by the Morgantown Energy Research Center. The economic feasibility of this technique will be evaluated. A preliminary gasification test is being designed for fielding late in FY 1977.

The FY 1978 operating expenses request of $11.0 million is an increase of $2.8 million over FY 1977. In addition, $1.6 million for Capital Equipment is requested for FY 1978. The major area of increases are for the Linked Vertical Wells, Steeply Dipping Beds and Environmental Support projects.

Figure 13 displays the major projects included under Operating Expenses for this subprogram.

FIGURE 13
In Situ Coal Gasification
1978 Funding

Major Projects	Millions	Performer	Location
Linked Vertical Wells	4.2	LERC, SLA	Hanna, Wyo.
Packed Bed	2.2	LLL	Hoe Creek, Wyo.
Deviated Wells, Longwall	1.2	MERC	Pricetown, W. Va.
Dipping & Dry Beds and Advanced Concepts	3.4	LERC, MERC LLL, LASL	Various

ALTERNATIVE FUELS DEMONSTRATION PROGRAM

Construction of plants required to meet projected synthetic fuel production needs in the 1990's must begin in the mid 1980's. Investment capital to build these plants will not be forthcoming unless uncertainties which impede such investments are resolved. Commercial demonstration plants which would resolve these uncertainties will require about 7 years to authorize and build. Lead times involved require construction and operation over the next 5 to 10 years of several commercial demonstration projects to ensure that the required synthetic fuels industry expansion will proceed smoothly and on a timely basis.

ERDA will propose to the Congress specific projects and project related authorizations and appropriations for various technology areas. Candidate projects will include plants of the following types: Oil Shale, High-Btu Gas, Substitute Fuel (Industrial Fuel Gas), Substitute Boiler Fuels, and Direct Combustion.

Administrative funds will provide for general program support and analytical studies on regulatory impacts, market constraints, environmental and socioeconomic impacts during construction and operation, and risk incentives involved in the program. Government obligations and outlays resulting from this program in excess of administrative expense will depend on the incentive options selected. The requested budget authority for FY 1978 is for $300 million which includes provisions for various incentive awards, including loan guarantees (which have a modest budgetary impact) and grants (which have a dollar-for-dollar budgetary impact).

ENERGY RESEARCH CENTERS AND NATIONAL LABORATORIES

The Energy Research Centers and National Laboratories are playing an important role in achieving the ERDA goals in fossil energy. These facilities are staffed by highly skilled scientists, engineers and technicians with long histories of accomplishments in the production and use of fossil fuels. They are looked to for new ideas, new data and new processes to better utilize our fossil energy resources, and project management (Figure 14).

To assist this Committee in its review of the Fossil Energy Program, we have included a summary table (Figure 15) displaying by program and subprogram, the appropriations requested. We look forward to continuing our relationship with the Committee and are pleased to have this opportunity to present our program.

Figure 14

Fossil Energy Development

Energy Research Centers/National Laboratories Support Activities

Research Center/ National Laboratory	COAL								
	Liquefaction	Gasification		Advanced Power Systems	Direct Combustion	Advanced Research & Supporting Technology	MHD	Demonstration Plants
		High Btu	Low Btu					
Ames Laboratory						Coal beneficiation, Alloy evaluation, and Development of fossil energy plants		
Argonne National Laboratory		High temperature/pressure samplers			PFB-CTIU, Fluidized-bed Combustion Studies	Materials technology for coal conversion processes	CDIF design & component development & paper, U-25 magnet test support	Demonstration plant technical support
Bartlesville Energy Research Center						Synthetic fuels product testing		
Brookhaven National Laboratory						Flash hydropyrolysis of coal, Regenerable sorbents for fluid-bed combustion		
Grand Forks Energy Research Center	Development of CO-steam liquefaction process		Gasification of coals by slagging ash, fluid-bed process		Sulfur-oxide emission control	Ash fouling studies		
Idaho National Energy Laboratory						High-temperature materials		
Laramie Energy Research Center								
Lawrence Berkeley Laboratory						High-temperature erosion-corrosion resistant materials development		
Lawrence Livermore Laboratory								
Los Alamos Scientific Laboratory								
Morgantown Energy Research Center		Development of hydrane process	Fixed-bed gasifier, Hot gas cleanup		AFB-CTIU fluidized-bed studies	Liquefaction studies Materials and component development, Combustion studies		Valve testing facility
Mound Laboratory								Technical support - Fuel gas demonstration plant
Oak Ridge National Laboratory						Materials and components development and testing		Environmental assessment of coal conversion technology, Coal conversion demo plant support & technical assistance
Pacific Northwest Laboratory			Hot gas cleanup with molten salt				Open-cycle MHD studies U-25 electrode/insulator coal development	
Pittsburgh Energy Research Center	Development of synthoil process, Recovery by gasification of synthoil solids, Hydrogenation of coal.	Synthane process, Hydrane process			Combustion testing for coal-oil slurries, Solid fuel combustion research facility	Comprehensive basic research program in coal fossil fuel development	High-temperature coal combustion studies for MHD technology.	Technical support for fossil demonstration plants
Sandia Laboratory				Diagnostic development for advanced power systems		Carbide & sulfide formation on alloys in coal processing environments	Numerical codes for MHD flows	

FIGURE 14
FOSSIL ENERGY DEVELOPMENT
ENERGY RESEARCH CENTERS/NATIONAL LABORATORIES SUPPORT ACTIVITIES

Research Center/ National Laboratory	PETROLEUM AND NATURAL GAS				OIL SHALE AND IN SITU COAL GASIFICATION	
	Gas and Oil Extraction			Processing & Utilization	Oil Shale	In Situ Coal Gasification
	Enhanced Oil Recovery	Enhanced Gas Recovery	Drilling and Exploration			
Ames Laboratory						
Argonne National Laboratory						Laboratory support for in situ coal gasification
Bartlesville Energy Research Center	Marker properties, Enhanced oil recovery technology support-monitoring & field testing	Production stimulation of fracturing	Improved drilling & safety methods	Characterization, processing, & utilization studies		
Brookhaven National Laboratory						
Grand Forks Energy Research Center						
Idaho National Energy Laboratory						
Lawrence Livermore Research Center	Thermal recovery & in situ support			Characterization of heavy liquid, vapidic studies	In situ retorting technology, Characterization of oil products, Environmental studies, Combustion of oil shale	In situ coal gasification technology development
Lawrence Berkeley Laboratory	Tertiary recovery with mobility & reactive tracers					
Lawrence Livermore Laboratory		Modern hydraulic fracturing			Modified in situ oil shale recovery	Development of packed bed process
Los Alamos Scientific Laboratory		Lenticular shale gas recovery project			Explosive fracturing of oil shale	In situ gasification of steam-water coals
Morgantown Energy Research Center	CO_2 flooding	Resource characterization-Devonian shale				Underground gasification of eastern coals
Moody Laboratory						
Oak Ridge National Laboratory	Chemicals for EOR, Identification of multiple tracers for ion exchange chromatography					Pyrolysis studies on large coal blocks
Pacific Northwest Laboratory						
Pittsburgh Energy Research Center						
Sandia Laboratory		Modern hydraulic fracturing R&D	Offshore drilling technology studies		Advanced instrumentation, diagnostics & cost analysis of retorts, In Situ bed preparation	Instrumentation & process control development for in situ field tests

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SUMMARY BY SUBPROGRAM

Operating Expenses	FY 1977 Estimate B/A	FY 1977 Estimate Obs.	FY 1977 Estimate B/O	Amended FY 1978 Estimate B/A & Obs.	Amended FY 1978 Estimate B/O
COAL PROGRAM					
1. Liquefaction	$ 72,957	$ 81,015	$ 84,983	$ 107,000	$109,800
2. High-Btu Gasification	44,054	53,021	58,704	51,200	42,800
3. Low-Btu Gasification	33,052	56,041	39,952	73,900	47,200
4 Advanced Power Systems	22,500	23,715	12,800	25,500	23,800
5. Direct Combustion	51,901	74,346	56,826	53,200	56,900
6. Advanced Research and Supporting Technology	37,070	38,727	36,570	40,000	42,000
7. Demonstration Plants	53,000	79,154	50,600	50,900 *	36,200 *
8. Magnetohydrodynamics	34,990	58,887	25,989	45,800	33,000
Total Coal Program	349,524	464,906	366,424	447,500 *	391,700 *
PETROLEUM AND NATURAL GAS PROGRAM					
1. Enhanced Oil Recovery	23,782	24,913	21,682	46,100	40,100
2. Enhanced Gas Recovery	14,874	16,643	11,274	27,000 *	23,500*
3. Drilling, Exploration and Offshore Technology	2,400	2,955	1,600	1,600	2,000
4. Processing and Utilization	1,831	1,789	1,831	1,400	1,400
Total Petroleum and Natural Gas Program	42,887	46,300	36,387	76,100*	67,000*
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM					
1. Oil Shale	22,278	27,020	13,323	28,000	21,500
2. In Situ Coal Gasification	8,236	8,720	6,736	11,000	12,000
Total Oil Shale and In Situ Technology Program	30,514	35,740	20,059	39,000	33,500
Operating Expenses	422,925	546,946	422,870	562,600*	492,200*
Capital Equipment	1,020	1,110	840	5,500	3,500
Construction Projects	59,200	80,860	21,700	88,800*	35,300*
TOTAL	$483,145	$628,916	$445,410	$656,900*	$531,000*

* Amended estimate.

FIGURE 15

AMENDED BUDGET JUSTIFICATION

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
GENERAL STATEMENT FOR OPERATING EXPENSES
FOSSIL FUEL AND RELATED PROGRAMS
(Dollars in thousands, except whole dollars in narrative material)

Estimate of Appropriation

The budget estimates for Direct Program Operating Expenses for FY 1978 provide for total obligations of $773,800,000 to be funded by a new appropriation.

Estimates of Costs and Obligations

The budget estimates for this appropriation are stated in terms of accrued costs for each of the direct operating programs. "Accrued costs" denotes the actual application of labor, materials and services to the program during the year, but excludes depreciation of facilities used in the operations. The ERDA does, however, maintain accounts for depreciation for the purpose of determining total costs of production and for use in establishing prices for services rendered or products sold to others.

The costs of operation are reconciled to the total obligations to be incurred during the year by estimating the buildup or decrease during the year of the resources that are to be applied to future years' operations. These estimates are included in the following summaries entitled "Change in Selected Resources" and include goods and services on order.

This section also includes a statement of the Reimbursable Program. It should be noted that the costs and obligations related to the Reimbursable Program are not financed by ERDA's appropriated funds, but solely through reimbursable agreements with other Federal agencies.

The following tables summarize the accrued costs and total obligations for Direct and Reimbursable Programs for fiscal years 1976, the Transition Quarter, 1977, and 1978.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL FUEL AND RELATED PROGRAMS
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Direct program:				
1. Conservation research and development:				
(a) End-use conservation and technologies to improve efficiency	$ 19,328	$ 17,823	$ 70,810	$ 162,050
(b) Energy extension service	0	0	5,000	6,000
Subtotal Conservation research and development	19,328	17,823	75,810	168,050
2. Fossil energy development:				
(a) Coal	201,181	77,697	366,424	384,200
(b) Petroleum and natural gas	21,498	9,340	36,387	63,000
(c) Oil shale and in-situ technology	15,241	4,555	20,059	33,500
Subtotal Fossil energy development	237,920	91,592	422,870	480,700
Total direct program costs	257,248	109,415	498,680	648,750
Reimbursable program:				
1. Fossil energy research and development	881	104	595	605
Total program costs, funded	258,129	109,519	499,275	649,355
Change in selected resources (undelivered orders)	99,555	51,152	147,539	125,050
10. Total obligations	$ 357,684	$ 160,671	$ 646,814	$ 774,405

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
(Continued)
FOSSIL FUEL AND RELATED PROGRAMS
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Financing:				
Receipts and reimbursements from:				
11.00 Federal funds	$ -938	$ -107	$ -595	$ -605
21.00 Unobligated balance available, start of period	-119,082	-179,343	-124,444	0
23.00 Unobligated balance transferred to other accounts	13,000	0	0	0
24.00 Unobligated balance available, end of period	178,802	124,444	0	0
25.00 Unobligated balance lapsing	0	541	0	0
Budget authority	429,466	106,206	521,775	773,800
Budget authority:				
40.00 Appropriation	443,516	109,086	521,775	773,800
41.00 Transferred to other accounts	-14,300	-2,880	0	0
42.00 Transferred from other accounts	250	0	0	0
43.00 Appropriation adjusted	429,466	106,206	521,775	773,800

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
(Continued)
FOSSIL FUEL AND RELATED PROGRAMS
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Relation of obligations to outlays:				
71.00 Obligations incurred, net	$ 356,746	$ 160,564	$ 646,219	$ 773,800
72.00 Obligated balance, start of period	193,008	292,506	343,655	491,194
74.00 Obligated balance, end of period	-292,506	-343,655	-491,194	-616,244
90.00 Outlays, excluding pay raise supplemental	257,248	109,415	498,680	648,750

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
CONSERVATION RESEARCH AND DEVELOPMENT
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Direct program:				
Conservation research and development:				
(a) End-use conservation and technologies to improve efficiency	$ 19,328	$ 17,823	$ 70,810	$ 162,050
(b) Energy extension service	0	0	5,000	6,000
Subtotal Conservation research and development	19,328	17,823	75,810	168,050
Total direct program costs funded	19,328	17,823	75,810	168,050
Change in selected resources (undelivered orders)	14,414	-2,970	23,463	58,150
10. Total obligations	$ 33,742	$ 14,853	$ 99,273	$ 226,200
Financing:				
21.00 Unobligated balance available, start of period	$ -2,978	$ -5,626	$ -423	$ 0
24.00 Unobligated balance available, end of period	5,626	423	0	0
Budget authority	36,390	9,650	98,850	226,200

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
CONSERVATION RESEARCH AND DEVELOPMENT
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Budget authority:				
40.00 Appropriation	$ 34,840	9,450	98,850	226,200
41.00 Transferred to other accounts	-1,800	-300	0	0
42.00 Transferred from other accounts	3,350	500	0	0
43.00 Appropriation adjusted	36,390	9,650	98,850	226,200
Relation of obligations to outlays:				
71.00 Obligations incurred, net	33,742	14,853	99,273	226,200
72.00 Obligated balance, start of period	833	15,247	12,277	35,740
74.00 Obligated balance, end of period	-15,247	-12,277	-35,740	-93,890
90.00 Outlays	$ 19,328	$ 17,823	$ 75,810	$ 168,050

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL ENERGY DEVELOPMENT
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Direct program:				
Fossil energy development:				
(a) Coal	$ 201,181	$ 77,697	$ 366,424	$ 384,200
(b) Petroleum and natural gas	21,498	9,340	36,387	63,000
(c) Oil shale and in-situ technology	15,241	4,555	20,059	33,500
Total direct program costs	237,920	91,592	422,870	480,700
Reimbursable program:				
1. Fossil energy research and development	881	104	595	605
Total program costs, funded	238,801	91,696	423,465	481,305
Change in selected resources (undelivered orders)	85,141	54,122	124,076	66,900
10. Total obligations	$ 323,942	$ 145,818	$ 547,541	$ 548,205

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL ENERGY DEVELOPMENT
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Financing:				
Receipts and reimbursements from:				
11.00 Federal funds	$ -938	$ -107	$ -595	$ -605
21.00 Unobligated balance available, start of period	-116,104	-173,717	-124,021	0
23.00 Unobligated balance transferred to other accounts	13,000	0	0	0
24.00 Unobligated balance available, end of period	173,176	124,021	0	0
25.00 Unobligated balance lapsing	0	541	0	0
Budget authority	393,076	96,556	422,925	547,600
Budget authority:				
40.00 Appropriation	363,532	88,756	422,925	547,600
42.00 Transfered from other accounts	29,544	7,800	0	0
43.00 Appropriation adjusted	393,076	96,556	422,925	547,600

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL ENERGY DEVELOPMENT
Program and Financing (In Thousands of Dollars)

Identification code: 89-0100-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Relation of obligations to outlays:				
71.00 Obligations incurred, net	$ 323,004	$ 145,711	$ 546,946	$ 547,600
72.00 Obligated balance, start of period	192,175	277,259	331,378	455,454
74.00 Obligated balance, end of period	-277,259	-331,378	-455,454	-522,354
90.00 Outlays	237,920	91,592	422,870	480,700

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE CHANGES - OPERATING EXPENSES

(Dollars in thousands, except whole dollars in narrative material)

The proposed changes in language are indicated as follows: language enclosed in brackets [ ] indicates proposed deletions, and underscoring _____ indicates proposed insertion of new language.

OPERATING EXPENSES, FOSSIL FUELS

For necessary operating expenses of the Administration in carrying out the purposes of the Energy Reorganization Act of 1974; hire, maintenance, and operation of aircraft; publication and dissemination of atomic and other energy information; purchase, repair, and cleaning of uniforms; reimbursement of the General Services Administration for security guard services hire of passenger motor vehicles; [$521,775,000] $773,800,000 and any moneys (except sums received from the Strategic and Critical Materials Stockpiling Act, as amended, and fees received for tests or investigations under the Act of May 16, 1910, as amended (50 U.S.C. 98h; 30 U.S.C. 7)) received by the Energy Research and Development Administration notwithstanding the provisions of section 3617 of the Revised Statutes (31 U.S.C. 484), to remain available until expended: Provided, That from this appropriation transfers of sums may be made to other agencies of the Government for the performance of the work for which this appropriation is made: Provided further, That the amount appropriated in any other appropriation act for "Operating expenses" for the Energy Research and Development Administration for the fiscal year ending September 30, [1977,] 1978, shall be merged with this appropriation [: Provided further, that no part of the sum herein appropriated shall be used for the field testing of nuclear explosives in the recovery of oil and gas: Provided further, That the funds made available under this head shall be available for obligation only upon the enactment into law of H.R. 13350, Ninety-Fourth Congress, or similar legislation: Provided further, That none of the funds herein appropriated for expenses related to fossil fuels shall be used to implement or finance authorized price support or loan guarantee programs unless specific provision is made for such programs in future appropriation acts]. (42 U.S.C. 5801, 5875; Department of the Interior and Related Agencies Appropriation Act, 1977; additional authorizing legislation to be proposed.)

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
PLANT AND CAPITAL EQUIPMENT
FOSSIL FUEL AND RELATED PROGRAMS

Program and Financing (In Thousands of dollars)

Identification code: 89-0103-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Capital Obligations (facilities and equipment) for:				
1. Conservation research and development: (b) End-use conservation and technology	$ 270	$ 183	$ 2,187	$ 1,670
2. Fossil energy development (a) Coal	14,740	4,600	81,110	89,200
(b) Petroleum and natural gas	100	9	360	600
(c) Oil shale and in-situ technology	200	226	500	2,500
Subtotal Fossil energy development	15,040	4,835	81,970	92,300
10.00 Total obligations 1/	15,310	5,018	84,157	93,970
Financing:				
21.00 Unobligated balance available, start of period (-)	0	-18,715	-21,937	0
22.00 Unobligated balances transferred from other accounts	-13,000			
24.00 Unobligated balance available, end of period	18,715	21,937	0	0
40.00 Budget authority (appropriation)	$ 21,025	$ 8,240	$ 62,220	$ 93,970

1/ Includes obligations for equipment not related to construction, as follows: FY 1976, $570 thousand; $418 thousand for the Transition Quarter; $3,297 thousand for 1977, and $7,170 thousand for FY 1978.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
PLANT AND CAPITAL EQUIPMENT
CONSERVATION RESEARCH AND DEVELOPMENT
Program and Financing (In Thousands of dollars)

Identification code: 89-0103-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Capital Outlay (facilities and equipment) for:				
Conservation research and development:				
(b) End-use conservation and technologies to improve efficiency .	$ 270	$ 183	$ 2,187	$ 1,670
10.00 Total obligations 1/	270	183	2,187	1,670
Financing:				
21.00 Unobligated balance available, start of period (-)	0	-330	-187	0
24.00 Unobligated balance available, end of period	330	187	0	0
40.00 Budget authority (appropriation)	600	40	2,000	1,670
Relation of obligations to outlays:				
71.00 Obligations incurred, net	270	183	2,187	1,670
72.00 Obligated balance, start of period	0	184	262	1,549
74.00 Obligated balance, end of period (-)	-184	-262	-1,549	-2,049
90.00 Outlays	$ 86	$ 105	$ 900	$ 1,170

1/ Includes obligations for equipment not related to construction, as follows: FY 1976, $270 thousand; $183 thousand for the Transition Quarter; $2,187 thousand for 1977, and $1,670 thousand for FY 1978.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
PLANT AND CAPITAL EQUIPMENT
FOSSIL FUEL AND RELATED PROGRAMS

Program and Financing (In Thousands of dollars)

Identification code: 89-0103-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Relation of obligations to outlays:				
71.00 Obligations incurred, net	$ 15,310	$ 5,018	$ 84,157	$ 93,970
72.00 Obligated balance, start of period	0	11,188	15,133	75,850
74.00 Obligated balance, end of period (-)	-11,188	-15,133	-75,850	-130,350
90.00 Outlays	$ 4,122	$ 1,073	$ 23,440	$ 39,470

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
PLANT AND CAPITAL EQUIPMENT
FOSSIL ENERGY DEVELOPMENT
Program and Financing (In Thousands of dollars)

Identification code: 89-0103-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Capital Outlay (facilities and equipment for:				
Fossil energy development:				
(a) Coal	$ 14,740	$ 4,600	$ 81,110	$ 89,200
(b) Petroleum and natural gas	100	9	360	600
(c) Oil shale and in-situ technology	200	226	500	2,500
10.00 Total obligations 1/	15,040	4,835	81,970	92,300
Financing:				
21.00 Unobligated balance available, start of period (-)	0	-18,385	-21,750	0
22.00 Unobligated balances transferred from other accounts	-13,000	0	0	0
24.00 Unobligated balance available, end of period	18,385	21,750	0	0
40.00 Budget authority (appropriation)	$ 20,425	$ 8,200	$ 60,220	$ 92,300

1/ Includes obligations for equipment not related to construction, as follows: FY 1976, $300 thousand; $235 thousand for the Transition Quarter $1,110 thousand for 1977, and $5,500 thousand for FY 1978.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
PLANT AND CAPITAL EQUIPMENT
FOSSIL ENERGY DEVELOPMENT
Program and Financing (In Thousands of dollars)

Identification code: 89-0103-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Relation of obligations to outlays:				
71.00 Obligations incurred, net	$ 15,040	$ 4,835	$ 81,970	$ 92,300
72.00 Obligated balance, start of period	0	11,004	14,871	74,301
74.00 Obligated balance, end of period (-)	-11,004	-14,871	-74,301	-128,301
90.00 Outlays	$ 4,036	$ 968	$ 22,540	$ 38,300

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U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE CHANGES - PLANT AND CAPITAL EQUIPMENT

(Dollars in thousands, except whole dollars in narrative material)

The proposed changes in language are indicated as follows: language enclosed in brackets [ ] indicates proposed deletions, and underscoring _____ indicates proposed insertion of new language.

PLANT AND CAPITAL EQUIPMENT, FOSSIL FUELS

For expenses of the Administration, as authorized by law, in connection with the purchase and construction of plant and the acquisition of capital equipment and other expenses incidental thereto necessary in carrying out the purposes of the Energy Reorganization Act of 1974, including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion [: $62,220,000]; $93,970,000, to remain available until expended: Provided, That the amount appropriated in any other appropriation act for "Plant and capital equipment for the Energy Research and Development Administration for the fiscal year ending September 30, [1977,] 1978, shall be merged with this appropriation [: Provided further, That the funds made available under this head shall be available for obligation only upon the enactment into law of H.R. 13350, Ninety-Fourth Congress, or similar legislation.]. (42 U.S.C. 5801, 5875; Department of the Interior and Related Agencies Appropriation Act, 1977; additional authorizing legislation to be proposed.)

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE CHANGES - GENERAL PROVISIONS

(Dollars in thousands, except whole dollars in narrative material)

The proposed changes in language are indicated as follows: language enclosed in brackets [ ] indicates proposed deletions, and underscoring _____ indicates proposed insertion of new language.

GENERAL PROVISIONS

SEC. 101. Not to exceed 5 per centum of appropriations made available for the current fiscal year for "Operating expenses" and "Plant and capital equipment" may be transferred between such appropriation, but neither such appropriation, except as otherwise provided herein, shall be increased by more than 5 per centum by any such transfers, and any such transfers shall be reported promptly to the Appropriations Committees of the House and Senate.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates

(Dollars in Thousands)

SUMMARY TABLE BY SUBPROGRAM

Conservation Research and Development

Operating Expenses	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
Electric Energy Systems and Energy Storage Systems											
1. Electric Energy Systems											
A. Bulk Power Delivery	$10,000	$ 8,819	$11,330	$ 2,100	$ 3,725	$ 2,808	$ 14,180	$ 14,404	$ 12,340	$ 22,522	$ 20,215
B. Power Systems Structure & Control	2,555	2,253	1,450	350	915	340	2,900	2,900	2,215	3,200	2,600
C. New Technology Integration	975	832	395	123	178	155	2,620	2,620	2,090	4,300	3,300
D. Field Test & Evaluation	0	0	0	0	347	0	3,300	3,300	2,575	6,678	5,985
Total Electric Energy Systems	13,530	11,904	13,175	2,573	5,165	3,303	23,000	23,224	19,220	36,700	32,100
2. Energy Storage Systems											
A. Batteries	7,322	8,030	4,942	1,784	1,241	2,849	13,300	13,800	9,920	16,320	12,675
B. Chemical/Thermal Energy Storage Systems	5,917	3,514	3,682	1,343	1,868	1,727	10,000	10,400	8,400	12,480	9,975
C. Mechanical Energy Storage Systems	2,686	1,401	1,644	560	1,845	1,082	4,400	4,599	3,700	6,050	4,900
D. Technical & Economic Analysis	1,243	1,226	1,409	243	260	77	2,100	2,200	2,000	4,150	3,250
E. Utility Applications	5,800	5,700	35	200	300	965	1,200	1,200	2,400	9,400	9,100
Total Energy Storage Systems	22,968	19,871	11,712	4,130	5,514	6,700	31,000	32,199	26,420	48,400	39,900
Total Electric Energy Systems & Energy Storage Systems	$36,498	$31,775	$24,887	$ 6,703	$10,679	$10,003	$ 54,000	$ 55,423	$ 45,640	$ 85,100	$ 72,000

SUMMARY TABLE BY SUBPROGRAM - continued (Dollars in Thousands)

Conservation Research and Development - continued

Operating Expenses	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
End Use Conservation & Technologies to Improve Efficiency											
1. Industrial Energy Conservation											
A. Waste Energy Reduction & Utilization	$ 489	$ 126	$ 55	$ 233	$ 240	$ 238	$ 2,625	$ 2,625	$ 2,174	$ 5,410	$ 3,500
B. Industrial Process Efficiency	2,437	1,841	772	203	324	321	5,865	5,865	5,536	13,580	9,910
C. Agricultural & Food Process Efficiency	646	542	169	323	398	417	3,430	3,430	1,975	4,800	3,570
D. Technology Transfer & Industrial Impact Analysis	1,656	1,284	1,033	250	1,342	476	2,510	2,629	2,275	1,210	1,120
Total Industrial Energy Conservation	5,228	3,793	2,029	1,009	2,304	1,452	14,430	14,549	11,960	25,000	18,100
2. Buildings & Community Systems											
A. Buildings Design and Structure	4,750	4,173	1,469	1,250	1,515	1,520	11,280	11,280	9,160	19,000	15,580
B. Community Energy Utilization	2,600	2,224	920	775	1,022	1,490	5,945	5,945	5,450	14,750	13,600
C. Urban Waste	1,079	2,202	594	750	1,889	1,397	4,450	4,450	3,700	7,500	6,000
D. Technology & Consumer Products	2,043	1,289	449	650	1,670	1,142	3,905	3,905	3,425	7,570	5,070
E. Consumer Motivation & Behavior	0	0	0	0	0	0	395	395	375	980	750
F. Economic Analysis & Technology Transfer	1,050	856	490	316	425	444	625	625	500	2,200	1,800
Total Buildings & Community Systems.	11,522	10,744	3,922	3,741	6,521	5,993	26,600	26,600	22,610	52,000	42,800
3. Transportation Energy Conservation											
A. Heat Engine Highway Systems	7,759	7,973	9,328	1,868	2,487	3,610	16,385	16,678	14,740	30,000	23,200
B. Alternative Fuels Utilization	733	338	128	212	465	354	1,785	1,785	1,550	2,380	1,900
C. Electric/Hybrid Vehicle Systems	1,605	1,486	789	340	407	29	5,000	5,000	4,000	46,900	26,250
D. Non-Highway Transport Systems	510	493	76	150	153	180	500	500	500	2,800	1,700
E. New Concepts/Impact Assessments	1,933	1,951	1,069	630	683	1,165	3,500	3,500	3,000	3,920	2,900
Total Transportation Energy Conservation	$12,540	$12,241	$11,390	$ 3,200	$ 4,195	$ 5,338	$27,170	$27,463	$23,790	$86,000	$55,950

SUMMARY TABLE BY SUBPROGRAM - continued

(Dollars in Thousands)

Conservation Research and Development - continued

Operating Expenses	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
4. Improved Conversion Efficiency											
A. Fuel Cell Technology	$ 3,674	$ 3,674	$ 421	$ 576	$ 640	$ 3,141	$19,000	$19,000	$ 9,450	$ 28,200	$ 26,900
B. Heat Cycle Technology	1,682	1,619	648	701	776	1,175	1,850	1,850	1,250	11,800	7,290
C. Combustion Technology	910	981	769	238	212	241	850	850	580	7,200	5,960
D. Supp. Tech./End Use Applications	834	690	149	185	205	483	1,450	1,461	1,170	8,000	5,050
Total Improved Conversion Efficiency	7,100	6,964	1,987	1,700	1,833	5,040	23,150	23,161	12,450	55,200	45,200
Total End Use Conservation & Technologies to Improve Efficiency	36,390	33,742	19,328	9,650	14,853	17,823	91,350	91,773	70,810	218,200	162,050
Energy Extension Service	0	0	0	0	0	0	7,500	7,500	5,000	8,000	6,000
Total Operating Expenses	72,888	65,517	44,215	16,353	25,532	27,826	152,850	154,696	121,450	311,300	240,050
Plant & Capital Equipment											
Electric Energy Systems and Energy Storage Systems											
Capital Equipment											
1. Electric Energy Systems	1,700	1,684	505	480	270	139	3,500	3,726	1,500	2,800	1,700
2. Energy Storage Systems	750	813	324	220	157	180	2,500	2,500	1,100	1,700	1,100
Total Capital Equipment	2,450	2,497	829	700	427	319	6,000	6,226	2,600	4,500	2,800
Construction Projects -											
Total	0	0	0	0	0	0	0	0	0	800	200
Total Plant & Capital Equipment Electric Energy Systems & Energy Storage Systems.	$ 2,450	$ 2,497	$ 829	$ 700	$ 427	$ 319	$ 6,000	$ 6,226	$ 2,600	$ 5,300	$ 3,000

SUMMARY TABLE BY SUBPROGRAM - continued (Dollars in Thousands)

Conservation Research and Development - continued

Plant and Capital Equipment	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
End Use Conservation & Technologies to Improve Efficiency											
Capital Equipment											
1. Industrial Energy Conservation	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 1,000	$ 1,000	$ 400	$ 500	$ 500
2. Buildings & Community Systems	0	0	0	0	0	0	0	0	0	170	170
3. Transportation Energy Conservation	400	133	23	40	120	20	500	687	200	500	100
4. Improved Conversion Efficiency	200	137	63	0	63	85	500	500	300	500	400
Total Capital Equipment	600	270	86	40	183	105	2,000	2,187	900	1,670	1,170
Construction Projects - Total	0	0	0	0	0	0	0	0	0	0	0
Total Plant & Capital Equipment End Use Conservation & Technologies to Improve Efficiency	600	270	86	40	183	105	2,000	2,187	900	1,670	1,170
Total Plant & Capital Equipment Conservation Research and Development	3,050	2,767	915	740	610	424	8,000	8,413	3,500	6,970	4,170
Operating Expenses	72,888	65,517	44,215	16,353	25,532	27,826	152,850	154,696	121,450	311,300	240,050
Capital Equipment	3,050	2,767	915	740	610	424	8,000	8,413	3,500	6,170	3,970
Construction Projects	0	0	0	0	0	0	0	0	0	800	200
TOTAL	$75,938	$68,284	$45,130	$17,093	$26,142	$28,250	$160,850	$163,109	$124,950	$318,270	$244,220

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
(Dollars in thousands, except whole dollars in narrative material)

FORWARD

CONSERVATION RESEARCH AND DEVELOPMENT

The main thrust of ERDA's Conservation Program is directed toward improving the nation's energy situation. Specifically, the objective of the program is to improve the efficiency of energy supply and use in industry, business, homes, and transportation. To be assured that the technologies are practical and economically acceptable, the programs work closely with industry, universities, and other government agencies in obtaining their objectives. The effectiveness of the programs continues to be dependent on the extent that users accept and employ the technologies.

The Conservation Program is organized into several broad areas with varied missions and methods for achieving goals and milestones.

In transportation, the main thrust is to work with the auto industry to commercialize fuel-efficient heat engines in the shortest possible time frame. In the buildings area, the approach is to work with industry and with, for example, The Department of Housing and Urban Development (HUD), State and local governments to bring new technology energy conservation into practice. In the industrial and energy conversion areas, the approach is to complement industry's interest in improved efficiency by sponsoring high-risk, high-payoff process developments and improvements. The thrust is to develop technologies that may lead to substantially more energy efficient products and applications in the next generation of energy systems. The important technology programs--namely Electrical Energy Systems and Energy Storage Systems--are closely coupled to the end-use areas of Conservation and to other programs within ERDA such as the Solar Program.

The justifications by Program which follow, outline in detail how the Conservation Program has planned to achieve its objectives. In FY 1978 emphasis on near-term research and development has been increased with the assumption that government and industry jointly will be responsible for near-term research, development and demonstration, particularly in the Buildings, Industry, and Transportation programs. Note: The FY 1978 request includes funds to support the Electric-Hybrid Vehicle Research, Development and Demonstration Act, 1976 (P.L. 94-413).

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Operating Expenses
(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT

END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY

PROGRAM STATEMENT

	B/A	Obs.	B/O
Estimate FY 1978	$218,200	$218,200	$162,050
Estimate FY 1977	91,350	91,773	70,810
Increase	$126,850	$126,427	$ 91,240

The overall objective of the End Use Conservation and Technologies to Improve Efficiency program is to conduct energy saving research, development and demonstrations in the three sectors that are the primary energy consumers of the Nation: Industry, Buildings, and Transportation; and the development of energy conversion techniques applicable to the End Use Sectors. To accomplish this objective this program proposes to:

- encourage and support the installation of energy efficient existing technologies;
- develop and implement new energy efficient technologies;
- develop and implement systems which will reduce the dependence on petroleum and natural gas; and
- disseminate information about existing and new technologies concerning energy efficient systems.

The End Use program organizationally is divided into four subprograms that address themselves to energy conservation in each consuming sector. A detailed examination of the Industrial Energy Conservation, Buildings and Community Systems, Transportation Energy Conservation, and Improved Conversion Efficiency subprograms follows:

SUMMARY OF ESTIMATES BY SUBPROGRAM

Page No.	Subprogram	Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual Transition Quarter B/A	Actual Transition Quarter Obs.	Actual Transition Quarter B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
8	1. Industrial Energy Conservation	$ 5228	$ 3793	$ 2029	$ 1009	$ 2304	$ 1452	$14430	$14549	$11960	$ 25000	$ 18100
31	2. Buildings & Community Systems	11522	10744	3922	3741	6521	5993	26600	26600	22610	52000	42800
57	3. Transportation Energy Conservation.	12540	12241	11390	3200	4195	5338	27170	27463	23790	86000	55950
72	4. Improved Conversion Efficiency	7100	6964	1987	1700	1833	5040	23150	23161	12450	55200	45200
	Total End Use Conservation & Technologies to Improve Efficiency	$36390	$33742	$19328	$ 9650	$14853	$17823	$91350	$91773	$70810	$218200	$162050

(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
1. Industrial Energy Conservation	B/A	$14,430	$25,000	+ $10,570
	B/O	11,960	18,100	+ 6,140

Category	Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual Transition Quarter B/A	Actual Transition Quarter Obs.	Actual Transition Quarter B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
A. Waste Energy Reduction and Utilization	$ 489	$ 126	$ 55	$ 233	$ 240	$ 238	$ 2,625	$ 2,625	$ 2,174	$ 5,410	$ 3,500
B. Industrial Process Efficiency	2,437	1,841	772	203	324	321	5,865	5,865	5,536	13,580	9,910
C. Agricultural and Food Process Efficiency .	646	542	169	323	398	417	3,430	3,430	1,975	4,800	3,570
D. Technology Transfer and Industrial Impact Analysis	1,656	1,284	1,033	250	1,342	476	2,510	2,629	2,275	1,210	1,120
Total Industrial Energy Conservation	$5,228	$3,793	$2,029	$1,009	$2,304	$1,452	$14,430	$14,549	$11,960	$ 25,000	$18,100

Objectives: The Industrial subprogram is directed towards significant reduction of energy consumption in the industrial/agricultural sector to be accomplished within an acceptable socio-economic-environmental framework. This objective will be achieved by increasing the overall efficiency (thermodynamic, mechanical, electrical) of industrial processes in a manner which is economically feasible in the related industries. The Industrial Energy Conservation subprogram is concentrating on new and innovative equipment and/or process changes which because of the high risk involved (technical and/or economic) industry would not pursue on its own. Through cost-shared research, development and demonstration of such technologies, their introduction into the industrial/agricultural sector is made possible or significantly accelerated. Related projects are cost-shared with industry and other Government agencies and are closely integrated with the activities of other ERDA organizations such as Solar Energy and Fossil Fuels.

The revised estimate for the FY 1978 Industrial Energy Conservation subprogram affords a logical continuity of growth in a critical activity directed at 42% of the total national energy consumption. Of the total revised estimate for FY 1978, representing an increase of 73% over FY 1977, 80% will be expended on activities which were initiated during prior funding periods. Such efforts will be accelerated during FY 1978 to provide a strengthened emphasis on near-term energy impact. A substantial number of these previously initiated projects will be advanced into and through the demonstration phase in FY 1978 to begin implementation in the industrial sector to expedite realization of the significant energy savings. In addition there will be significant new projects started in FY 1978 affording near and mid-term energy impacts to capitalize on many of the additionally known but untapped industrial energy conservation opportunities. In summary, the FY 1978 subprogram includes significant efforts in waste heat recovery, co-generation systems, substitute fuels and materials,

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

advanced aluminum and steel processes, advanced fertilizer development, significant energy saving processes in textiles and paper manufacturing and a major effort for collective utilization of waste energy in energy integrated industrial parks. In addition, the effort for FY 1978 exemplifies an increased degree of integration of other Government funded efforts. An example of this is a project funded jointly by ERDA and EPA with the dual results of reducing pollution in glass processes simultaneous with significant savings of energy. On a monthly basis ERDA and other Government agencies (including DOC, FEA, NSF, USDA and FPC) meet to review programs and results of programs to ensure that no redundancy of effort exists and to disseminate the results of ERDA's efforts to the other agencies having close contact and relationships with industry.

The FY 1978 revised budget estimate will serve to advance a substantial number of Industrial Energy Conservation activities so as to realize a significant near-term energy impact and to initiate energy-savings efforts in some of the heretofore untapped but known important opportunities. The analytical planning efforts and the initial starts of previous funding periods will be brought into maturity in FY 1978 - the first year of significant contract completions for the relatively new subprogram.

Federal Role: The industrial sector consumes 42 percent of the Nation's energy using current practices and techniques. It is estimated that between 30 and 50 percent of this energy could be saved through the universal application of existing, emerging, and advanced technologies. Such a savings, if effected by 1985 would amount to 12 to 20 million BPDE (again assuming universal application) and could essentially eliminate U.S. dependence on uncontrollable foreign supply of petroleum, especially in the critical time period before new synthetic and nuclear supply systems emerge. The FY 1978 budget reflects market penetration in the amount of ten percent used in establishing the actual program goals. When public monies are expended in the private sector, several basic tenets must be observed:

- Federal funds should not be expended in cases where industry would have developed and introduced a technological innovation on its own.
- No single company should be given an unfair competitive advantage.
- The proprietary interests of individuals or corporations must be respected and protected.
- The company and/or industry assisted by Federal funds should share monetarily in the introduction of the innovation.

From an industry standpoint several other factors must be acknowledged:

- The introduction of a process change or technical innovation often involves an R&D expenditure and always involves a capital expenditure.
- Industry will apply its historical evaluation criteria of expenditures in assessing the relative merits of introducing energy conservative technologies, e.g., competitive position, return on investment, availability of capital, etc.

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

Three major factors are involved in evaluating the introduction of new energy conservative technologies: risk, cost and benefit. Risk and cost are closely related since the feasibility of a new technology depends not only on its technical merit, but on its economics of introduction. Likewise, benefit and cost are related since the energy saved (benefit) per unit of output determines the reduction in operating costs. Finally, risk is related to benefit in that the higher the benefit the more willing a company would be in taking a risk. The spectrum of such factors are qualitatively shown within the following table:

Spectrum of Technologies Applicable to Industrial Energy Conservation

Major Factors	Low Risk	Intermediate Risk	High Risk
• Status of technical feasibility (risk)	Proven	Laboratory test verification	Analytical feasibility shown
• R&D expenditure required (cost)	None	Small	Intermediate to high
• Demonstration expenditure required (cost)	None	Intermediate to high	High
• Accuracy of estimated cost of production equipment (cost)	High	Intermediate	Low
• Accuracy of predicted installation, operating and maintenance costs (cost)	High	Low	Low
• Accuracy of return on investment analysis (benefit and risk)	High	Intermediate	Low
Examples:	• Application of insulation	• High temperature recuperators	• Brayton cycle in a glass kiln
	• Steam trap repair and maintenance	• Coil coating oven modifications	• CO as a feedstock

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

It is significant to note that six major industry categories consume about 70 percent of the total energy in the industrial sector and that these industries (chemicals, petroleum refining, primary metals, pulp and paper, cement, and food processing) are all "commodity industries" i.e., they involve the production of intermediate materials used in the manufacture of end products. In industries of this type, several characteristics influence their willingness to introduce new technologies.

- They are production oriented; they have maximized their facilities with regard to reliability, production capacity and simplicity.
- They are capital intensive -- the cost of their basic equipment is usually extremely high.
- They are not R&D oriented -- the monies they spend are largely devoted to developing new markets for their commodities.

In light of these factors, such industries are usually reluctant to introduce new technologies unless such technologies are very well proven in a production environment, do not significantly increase their capital investment per unit product, and save production costs to the extent that their internal return on investment is high (30%). In many such industries very little R&D funds are devoted to improving production efficiency. Capital expenditures are made primarily in the area of replacing used or worn equipment in an existing production line. New production facilities that are built generally follow the well established and proven technologies.

Industry (especially the commodity industry described above) will likely pursue and implement those programs of low technological risk whose economic attractiveness is clearly determined. Higher risk programs which have high potential benefit usually must be demonstrated by joint ERDA-Industry funding if they are to achieve industrial acceptance and implementation. In such demonstrations, the economic viability as determined by return on investment on the projected capital cost of production units must be included.

Thus, the major thrust of the ERDA Industrial Energy Conservation subprogram will be to demonstrate technologies that:

- Industry would not pursue on its own primarily because of the high risks involved.
- Have high potential benefit in terms of energy savings.
- Significantly accelerate energy savings.
- Promise significant savings in fragmented industries which have no research funds allocated to such effort.
- Have a return on investment which once developed, will sufficiently attract broad scale implementation.

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- Are cost-shared by the industries affected.

- Are conducted by industries willing to license any patentable features to competitors at a reasonable fee.

In summary, there are numerous significant areas of research and development directed towards this subprogram that industry is already pursuing or will pursue without Government assistance. There are, however, combinations of cost, benefit and technical risk where industry, alone, will not attempt to pursue a more rapid avenue of approach. On a selective basis these are the opportunities for the Federal role.

Accomplishments: Since its inception in August 1975, the Industrial Energy Conservation subprogram has initiated a wide variety of key projects across the broad spectrum of industrial processes in order to start conservation activities on the broad industrial/agricultural front. Key projects were started for demonstrating new, but unproven technologies; major efforts were competitively initiated by Program Opportunity Notices (PON's); project planning and targeting analyses were undertaken to identify and prioritize energy-saving potentials in the industrial sector; and several conceptual analyses were performed to explore promising potential demonstration projects for later time frames. Key specific accomplishments to date are summarized as follows:

- A new system for saving natural gas in paint curing lines is two and a half months ahead of schedule and a full scale demonstration will begin March 15, 1977. This system uses the paint vapors as fuel by incinerating within the oven with an estimated natural gas savings of up to 80%. The total potential estimated annual savings is .16 Quadrillion Btu's with the energy impact starting this year with at least ten such systems on order by industrial finishing concerns.

- An air/fuel ratio control for industrial boilers was developed, fabricated and is being installed in an industrial application for a demonstration in March 1977. This system implemented across industry will significantly impact the 12 Quadrillion Btu's consumed in industrial steam generation annually.

- Industrial waste heat recovery systems are currently being designed and fabricated on two major contracts and four additional contracts are being expedited. These units, applicable to the energy intensive exhaust streams in aluminum remelt, glass melting, cement kilns, steel soaking pits and reheat processes, have demonstrations beginning in early 1978 and are directed towards recovery of the estimated 10 Quadrillion Btu's of energy currently being exhausted by key industries each year.

- Contracts are in final phases for three industrial heat pump development and demonstration projects. This effort is directed toward recovery of industrial waste heat of temperatures below 250°F. Demonstrations will begin in 1978.

(Dollars in thousands, except whole dollars in narrative material)

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- A contract is being completed for demonstration of coal as a fuel to replace natural gas in the energy-intensive aluminum remelt operations. This important demonstration of alternative fuel will be performed in 1978.

- A planning study for energy-integrated industrial parks is in process and a Program Opportunity Notice (PON) will be issued in FY 1978 to solicit proposals for specific demonstration projects for collective utilization of energy in industrial park complexes.

- Major efforts are being initiated in FY 1977 which will result in key demonstrations in FY 1978 and subsequent periods. Such include improved processes for production of aluminum and steel, food sterilization by non-thermal means, electrically-charged fabric filters, improved textile dyeing/drying processes, improved paper dewatering processes, poultry process improvements, crop irrigation systems, and a variety of industrial waste recovery activities.

- A joint ERDA/EPA project was initiated in FY 1977 on improved glass melting processes by preheating from waste heat. In FY 1977 the systems analyses and designs will be completed and long lead procurement items will be ordered. During FY 1978, the pilot facility will be completed and pilot tests will be conducted pursuant to a full scale demonstration in later funding periods.

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- Demonstrations are currently in process for meat packing improvements, moving beam furnace modifications, cupola furnace modification, aluminum smelter modifications, and vacuum blanching in vegetable canning processes.
- Studies and analyses are being conducted for a variety of applications and for program planning purposes. These include: Conservation in steel and paper industries, an input/output model for energy conservation, energy characteristics of powered handtools, in-plant power generation, conservation opportunities in distillation columns, irrigation pumping alternatives, new fertilizer processes, insulation, refractories, blended cement, paper recycling and materials optimization analyses.
- Projects are being initiated during FY 1977 for development and demonstrations of foam dyeing technology for textile processing and increased efficiency in paper pulping processes.

Revised Budget Request: The revised FY 1978 request for $25,000,000 in budget authority is an increase of $10,570,000 over the FY 1977 level. Operating costs of $18,100,000 requested for FY 1978 is an increase of $6,140,000 over FY 1977. The major areas of increase include the timely expansion and acceleration of a substantial number of previously-initiated projects so as to affect a significant near-term energy impact. Many previously-started projects will reach the demonstration hardware phase in FY 1978 thereby increasing the funding requirements accordingly. The FY 1978 Budget increase also affords initiation of selected new project starts for some of the important but currently untapped energy conservation opportunities in the industrial sector.

The Budget request for each of the subprogram categories is shown in the following paragraphs along with constituent project descriptions and justifications:

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
A. Waste Energy Reduction and Utilization.....	B/A	$2,625	$5,410	+$2,785
	B/O	2,174	3,500	+ 1,326

This category is directed at reducing the energy lost through waste energy of industrial processes by improvements in equipment and processes that are common to many industries. There are a variety of approaches to the reduction of waste energy and each will be covered in this category. The following summarizes the sequences and projects for this category in FY 1978:

(Dollars in thousands, except whole dollars in narrative material)

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Category Activity:	IMPROVED FUEL CONVERSION	IMPROVED PROCESS ENERGY USE EFFICIENCY	RECOVERY OF WASTE ENERGY AND MATERIAL	REUSE OF RECOVERED WASTE ENERGY AND MATERIAL
FY 1978 Projects:	• Catalytic Combustion in Industrial Boilers* • Follow-on Demonstration of Boiler Air/Fuel Ratio Control	• Fabric Filtration • Insulation Study • Refractories Study	• High Temperature Recuperators • High Temperature Heat Pumps • Stirling Cycle Heat Pump Study	• Demonstration of Rankine* Bottoming Cycles • Demonstration of Brayton Cycle in the Glass Industry* • Inplant Power Generation Study

*The initial phases of these projects are being conducted by the improved energy conversion subprogram with funding support by the Industrial Energy Conservation subprogram to which such projects will transition at a later development phase.

During FY 1976 and the Transition Quarter, Program Opportunity Notices (PON's) were issued and six contracts were initiated for High Temperature Recuperators (Heat Recovery Devices) for high efficiency recovery of the significant waste heat from flues of steel, aluminum, glass, cement, soaking pits and fume incinerator applications. The application surveys, conceptual analyses and development of design parameters will be completed during FY 1977 as well as the start of demonstration unit fabrication. During FY 1978, a total of six demonstration projects will be conducted including aluminum remelt, steel reheat, glass melting and cement processes. Also, as a result of a PON, three contracts will be initiated in FY 1977 for development of High Temperature Heat Pumps. During FY 1978, this work will be continued pursuant to demonstrations in FY 1979. Catalytic combustion in industrial boilers was the subject of another PON and the FY 1977 activity is being managed by the Improved Conversion Efficiency subprogram. A contract will be awarded in FY 1977 for the project which is directed towards improvement of steam generation efficiency to over 90% and reduction of stack temperatures in boilers. During FY 1977 design parameters will be determined and feasibility will be analyzed. The project will then transition into the Industrial Energy Conservation subprogram and demonstration units will be fabricated.
The following are brief descriptions of other projects which were initiated earlier and are continuing in FY 1978:

- Fabric Filtration: This is a study of techniques using electrical charges across Fabric Filters to improve the energy utilization efficiency and improved filtration efficiency in "Bag House" Fabric Filters. "Bag Houses" are the waste stream filtering facilities of smelters, calciners, etc. During FY 1977, a study will be conducted and design parameters will be developed. During FY 1978 demonstration equipment will be designed and fabricated for a demonstration.

(Dollars in thousands, except whole dollars in narrative material)

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- Insulation Development: Greater utilization of high temperature fibrous insulation for retrofit of furnaces can be obtained through demonstration of the materials performance. In FY 1977, thermal property data are being developed in the laboratory for general classes of fibrous insulation materials. Temperature and thermochemical limitations are being defined for each general class of insulation. During FY 1978, field data are to be obtained for the performance of the fibrous insulation materials. Correlations of laboratory and field data will be made to define installation design parameters. Field tests will be conducted within various industries to demonstrate applicability to range of industrial requirements.

- Refractories Development: The project is to provide industry with a technical basis for selection of refractories resistant to the corrosive effects of alternate fuels (e.g., residual oil and coal). Since start-up in FY 1976, a literature/industry survey has been completed and a topical report has been published. A fuel oil combustion test facility was installed and generic types of refractories screened as to their relative resistance to impurities in oil fuels. Also, design requirements for a coal fired test facility are being identified. With continuation of the project in FY 1978, oil-combustion corrosion data on hundreds of hours of tests will be obtained on selected refractories in laboratory facilities. Laboratory screening tests will be initiated for refractories exposed to coal combustion products.

- Catalytic Combustion in Industrial Boilers: This project for the improved efficiency in industrial steam generation by catalytic combustion technology was initiated as a Program Opportunity Notice (PON) in FY 1977 and responsive proposals are currently being evaluated. The first phase design analysis and laboratory feasibility studies will be conducted by the Improved Energy Conversion subprogram during FY 1977 and the project will be transitioned to the Industrial Energy Conservation subprogram following a successful first phase.

- Stirling Heat Pump Study: A significant portion of process heat demand occurs at temperatures above 400°F. Present Rankine heat pump systems are limited for these applications to relatively low coefficients of performance (COP's). They are further limited by the lack of available suitable working fluids. Various non-conventional heat pump cycles, such as Stirling and Brayton, however, employ gaseous working mediums, such as argon, nitrogen, hydrogen and helium. These gases are not limited by thermal instability or material compatibility considerations. These cycles offer the potential for outperforming the traditional Rankine cycle. A 1-year study program will be initiated in FY 1978 to evaluate the feasibility and performance of the Stirling cycle as an ultra-high temperature (greater than 400°F) heat pump, based on design, costs, reliability, and other criteria.

- Follow-on demonstration for boiler fuel/air ratio control: A boiler fuel/air ratio control system was developed under a contract initiated during a prior funding period. The system is now being readied for the start of an initial demonstration in March 1977. The system features a spectral flame analyzer for feedback control of excess air for individual burners in an industrial boiler. This project is a second demonstration of the system to accelerate the widescale industrial implementation.

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• In-Plant Power Generation Study: This 8 month study is a follow-on to a FY 1976 study which evaluated advanced technology and components applications to in-plant industrial power generation in three industries (paper, chemicals, and petroleum). This program includes the selection of candidate processes for co-generation, with and without energy storage in four major industries (paper, chemicals, petroleum, and metals) and examines demand characteristics, and inter-relationships, and evaluates the compatibility with different types of co-generation equipment including, steam turbines, fuel cells and diesels. During FY 1977 twelve candidate industrial processes were selected for investigation and evaluated for their compatibility with various types of co-generation equipment. During FY 1978 the evaluation of co-generation compatibility will be completed in addition to a detailed cost/benefit analysis and recommended RD&D programs.

• High Temperature Recuperators: Six contractors were selected from responses to a Program Opportunity Notice (PON) issued in FY 1976 for development and demonstration of high efficiency heat recovery devices operating at 1200°F to 3000°F in the exhaust streams of steel reheat, steel soaking pits, and glass melting furnaces. During FY 1978 the initial demonstrations will be initiated on this major effort directed at industrial waste heat.

• High Temperature Heat Pumps: This project was initiated in FY 1976 with the issuance of a Program Opportunity Notice (PON). Awards of three contracts will be made during FY 1977 for development and demonstration of three industrial heat pumps (Rankine; Rankine-Rankine; Brayton), capable of taking discharged waste liquids (150-250°F) and thermodynamically "pumping" it to use process heat temperatures (300-400°F) at a COP* of between 3.0 to 3.5. To put this figure (COP) into perspective, corresponding heater efficiencies as COP's would be: gas heaters (less than .69); oil fired heaters (less than .55) and electric heater (less than .30). During FY 1977, efforts will consist of application analysis to study available working fluids, heat exchangers, compressors and lubricants. During FY 1978, prototypes will be designed and fabricated combining optimum available components. These units will be installed in an industrial environment (chemical, food, paper) and demonstrated in FY 1979.

• Demonstration of Rankine Bottoming Cycles: In industries using direct (low efficiency -- about 25%) heating furnaces (glass, steel, reheat, aluminum remelt, etc.), where stack temperatures are high, recuperation of this energy enables the application of several bottoming cycles (closed Brayton cycles, steam Rankine, organic Rankine). Since the electrical power produced from the waste heat has no fuel cost, the primary expense consideration is the capital investment to produce the power. The FY 1978 project will demonstrate two organic Rankine cycles 600 Kw(e)0 bottoming systems coupled to five selected industrial/utility waste heat sources to produce electricity at an estimated 18% efficiency.

• Demonstration of Brayton Bottoming Cycles in the Glass Industry: This project is directed toward the design, development and demonstration of an open Brayton cycle turbine to recover energy from high temperature (1200-1700°F) industrial gaseous waste streams such as those found in the glass industry. During FY 1977 work will be accomplished toward completing a survey of the applications. In FY 1978 the application analysis and system specification will be finished, in addition to the site selection and layout. Component development and preliminary design of the selected system will be completed

* Coefficient of performance.

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and detailed system design work initiated.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
B. Industrial Process Efficiency	B/A	$5,865	$13,580	+$7,715
	B/O	5,536	9,910	+ 4,374

This category is directed towards improvement of processes within specific energy intensive industries to reduce the energy consumed per unit product and to conduct research, development and demonstration of techniques for substituting inexhaustible energy for oil and natural gas in industrial processes. The following summarizes the projects for this category in FY 1978 by sequence of activity:

Catetory Activity:	SYSTEMS ANALYSIS	APPLICATIONS ANALYSIS	DESIGN AND DEVELOPMENT	DEMONSTRATION AND TECHNOLOGY TRANSFER
FY 1978 Projects:	• External Desulfurization • Blended Cement • Program Management and Systems Analysis • Energy Monitor in a Refinery • CO as a Feedstock • N_2 Based Steel Carburization • Energy Management in an Integrated Paper Plant	• Dry Coke Quenching • Energy Integrated Industrial Park • Coal in Aluminum Remelt • Metals Extraction • Industrial Materials and Waste Systems • Low Energy Silicone Production • Improved Radiant Tube Furnace	• Electric Arc Furnace Modification • Alternates to Natural Gas in Curing Coil Coated Materials • O_2 Enrichment • Continuous Casting of Steel • Direct Reduction of Aluminum • Acetylene From Coal • Electric Arc Welding Power Supply	• Fuel Fired Scrap Heat • Aluminum Electrolytic Smelter Modification • Fuel Saving System for Curing Paint • Glass Conglomerates • Moving Beam Furnace Modification • Computer Controls in Small Chemical Plants

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The following paragraphs briefly describe those activities which were initiated in prior funding periods and are continuing in FY 1978 and the key new starts in FY 1978:

• Blended Cement: The objective of this project is to reduce the energy consumed in the manufacture of portland cement by blending fly ash or slag with the kiln-fired cement. Commercial acceptance of the blended cements to be promoted through development of property data and the modification of existing ASTM specification standards. Since start-up in FY 1976, property data were developed that are needed for modification of ASTM specification C-595. Also, other test methods (e.g., corrosion and freeze-thaw) were evaluated for suitability for blended cement products and recommendations submitted specification modifications. For the continuing programming in FY 1978, technical data necessary for the development of performances oriented specification standards for blended cement will be obtained.

• Glass Conglomerates: The objective of this project is to reduce both the energy requirements and air-borne pollutants for glass melting furnaces. High temperature exhaust gas from the melting furnace will be utilized to pre-heat and conglomerate the fine particles of the glass furnace charge. The program is jointly funded by ERDA and EPA. During FY 1977, materials and process parameters for conglomeration of the glass charge are being defined through laboratory analysis tests. Pilot-plant design will be 75% complete and procurement of long-lead time items will be initiated. A detailed energy analysis of the proposed process will be completed. Within the FY 1978 period the pilot-plant facility is to be completed and tests run to determine operating parameters and to define design parameters for full-scale demonstration.

• Energy Monitor In A Refinery: The objective of this 20 month project is to develop a technique for auditing energy consumption in an oil refinery, instrument and audit the energy consumption within a large refinery, document and disseminate the results and prepare a handbook on "How to Audit Energy in a Refinery." In FY 1977 the selections of process blocks within the large refinery will be made and raw data collected on a sample block and reviewed prior to proceeding. In FY 1978 the project will be completed, i.e., the total refinery audit will be completed and the documented data will be disseminated.

• Arc Welding Power Supply: This project is directed toward the development and demonstration of a highly efficient (85-90%) arc welding power supply. Conventional welding power supplies exhibit real power efficiencies of 45-65% and have undergone little or no evolution for 40 years. During FY 1977, several welding power supply concepts will be

analyzed and designed. In FY 1978, several engineering prototypes will be fabricated and subjected to in-plant and industry testing.

- Program Management and Systems Analysis: This is a project funded at the Idaho National Engineering Laboratory to provide project management on selected programs, evaluation of proposals and performance of systems analyses in key areas in support of the Headquarters staff. This is a principal activity related to decentralized management of the subprogram.

- Aluminum Electrolytic Smelter Modification: Contracts were initiated during FY 1976 for the design and testing of systems which impart substantial electric power savings and increased productivity to existing aluminum reduction cells. Test units are being installed and operated in FY 1977. The effort in FY 1978 will scale up the test unit dimensions to prove the concept in industrial applications

- Energy Optimized Industrial Park: This project relates to the establishment of industrial parks with industries selected and positioned so as to efficiently utilize waste energy outputs of some as process energy inputs for others as well as to integrate waste materials and feedstocks. During FY 1977 a Phase I study will be completed to collect and analyze specific industry data, select mixes of industries and technology, and determine key program planning data. FY 1978 effort, to be initiated by a FY 1977 Program Opportunity Notice (PON), will be directed towards specific system design, test phase definition, and initial implementation of steps leading to a full scale demonstration in subsequent funding periods.

- Metal Extraction: Development and demonstration of a new process for extracting copper or chromium from low grade ores by placing the ore in a chlorine atmosphere where the metal reacts with the chlorine to form copper or chromium salts from which the metal is extracted by distillation and the chlorine is recycled. This eliminates many energy-intensive steps in the conventional process. Lab scale tests and preliminary economic feasibility analyses will be completed in FY 1977. During FY 1978 lab tests will be continued and components will be developed for a pilot plant demonstration.

- Fuel Saving System for Paint Curing: A contract was initiated in FY 1976 for the demonstration of a system on a coil coating line to use the fumes of paint as a fuel source for curing the paint. The unit is being installed in FY 1977 and the demonstration will begin March 15, 1977. The FY 1978 effort will consist of the analysis of the results and initiation of Technology Transfer seminars.

- Coal in Aluminum Remelt: A Program Opportunity Notice (PON) was published during FY 1977 and a contract is being initiated. The goal is to demonstrate the commercial application of melting aluminum in reverboratory furnaces fueled

with pulverized coal. The effort in FY 1978 will be to demonstrate the efficiency of equipment designs and acceptance of direct-fired coal fuels in this basic metallurgical process now fired by natural gas and oil.

• Fuel Fired Steel Scrap Melter: The direct use of fuel in the melting of steel scrap is the objective of this research. This new start in FY 1978 conserves much of the energy lost in converting fuel to electric power and to operate electric arc furnaces. During FY 1978 the feasibility will be analyzed and evaluated.

• Moving Beam Steel Slab Heaters: This project was initiated in FY 1976 for a new method for transporting heavy steel slabs weighing 30 tons or more through furnaces at temperatures exceeding 2400°F. This is an intermediate step which will permit the design of furnaces or retrofit of existing furnaces to operate at greater thermal efficiency. In 1978 the demonstration furnace will be designed and energy optimized including the monobeam equipment. A demonstration will be conducted in FY 1979 or FY 1980.

• Electric Arc Furnace Study: This new start in FY 1978 is a study which will simulate the operation of an electric arc steel scrap melting furnace via a computer. Different modes will be analyzed to improve the efficiency of electric power utilization. During FY 1978 data collection will be completed and the simulation program developed pursuant to completion in FY 1979.

• Oxygen Enrichment: This project is directed toward the demonstration of systems capable of producing air enriched oxygen as a means of improving the efficiency of combustion processes. This project is targeted at a broad range of industrial combustion processes which use natural gas, all grades of fuel oil and coal as a fuel. During FY 1977 a Program Opportunity Notice (PON) will be issued for development of a system to provide oxygen-enriched air for combustion processes. During FY 1978, contractors will be selected and effort will be initiated to conduct industry surveys, perform comparative analysis and complete preliminary engineering designs.

• Dry Coke Quenching: The objective of this new project start in FY 1978 is to capture the 2000°F sensible heat in coke discharged from steel industry coke batteries in an environmentally satisfactory manner. This is to be done by gas-to-gas heat transfer with the hot charge centered in an inert gas atmosphere as opposed to present wet quenching in which sensible heat is wasted to the atmosphere. During FY 1978 engineering feasibility studies, economic analyses and environmental assessments will be completed.

• Industrial Materials and Waste Systems: This activity relates to a series of efforts directed towards recovery and utilization of industrial waste materials. Individual efforts include conversion of atactic polypropylene waste to fuel oil (which started with reactor modification in FY 1977 and demonstration will be conducted in FY 1978); waste tires as a fuel (A PON will be issued in FY 1977 and the contract will be negotiated in FY 1978 to develop and demonstrate an efficient utilization process); reduced float glass waste through ripple sensors and controls (analysis and design will be done in FY 1977 with fabrication and installation to be done during FY 1978); synthetic aggregates for pavement; animal

fats for detergents; lube oil recovery; pulp/paper sludge recovery and auto plastics recovery.

• Low Energy Silicone Production: This project will be funded in FY 1977, and initially includes feasibility studies for reducing the large amounts of energy now used in manufacturing silicones. Silicones are used extensively in the electric equipment and power distribution industries and there are indications of a rapidly expanding role for these materials. This project is aimed at reducing or eliminating the need for producing silicon metal in the production of silicones from sand.

• Improved Radiant Tube Furnace: The metals industries consume large amounts of natural gas in furnaces heated by radiant tube heaters. The annealing process is a vital step in metal processing and in this new FY 1978 project attempts will be made to modify equipment designs to make radiant tube heaters more efficient and possibly replace them with heaters using less critical fuels. Activity during FY 1978 will consist of engineering feasibility studies and computer simulations.

• Nitrogen-based Carburization of Steel Parts: Present practice uses an endothermic atmosphere produced by catalytically reforming a controlled mixture of natural gas and air. The nitrogen-based carburizing process provides carbon monoxide and hydrogen in the furnace atmosphere at a concentration well below that of endothermic gas, thus saving 75% of the natural gas used. This is possible because the carbon dioxide content is substantially lower in the nitrogen-based atmosphere and because carbon potential in the furnace depends on the relative concentration of the carburizing carbon monoxide versus that of the inhibiting carbon dioxide as well as temperature. This effort will begin in FY 1977 with design and start of modification of four heat treat furnaces. In FY 1978, the activity will consist of completion of modifications and demonstration.

• External Desulfurization: Increasing amounts of limestone are charged into blast furnaces to combine with and retain most of the sulfur in the materials charged into the furnace. Lowered amounts of limestone directly reduce the amount of metallurgical coke required. This can only be done if hot metal is desulfurized external to the blast furnace using other materials which react with and retain the sulfur. This proposal will develop a demonstration unit in a major steel complex to develop practices and procedures which are most energy conserving. This is a new project start in FY 1978 during which the activity will consist of design feasibility studies and energy benefit analyses.

• Continuous Casting of Steel: A contract will be initiated during FY 1977 to design and test a facility which will cast and hot roll steel eliminating the energy intensive steps (billet casting, hot rolling and reheating). The effort in FY 1978 will continue this work leading in the near future to commercial scale.

• Direct Reduction of Aluminum: A contract will be awarded in FY 1977 to initiate feasibility studies concerning the direct reduction of aluminum from ores thus eliminating the energy intensive process of electrolytic smelting. Since electrolytic smelting of aluminum uses large amounts of the electrical power resources, success of this effort will be

extremely important in reducing power needs in the future. These studies will be completed and, if feasibility is indicated, design will be completed during FY 1978.

• Production of Acetylene from Coal: The Arc-coal process for producing acetylene from coal has been developed through the laboratory stage under sponsorship of the Office of Coal Research. In FY 1977, pilot-plant studies will be initiated by development of a process reactor of 1 megawatt capacity and by performing design analysis of the proposed pilot-plant facility. During FY 1978 designs will be finalized and hardware for demonstration will be fabricated.

• Computer Controls in Small Chemical Plants: This is a new project, in FY 1978, designed to demonstrate the economic and technical feasibility of computerized process control in a variety of small plants. The use of computers to improve control of industrial processes has a history of about 15 years, but it is estimated that in 1973 no more than ten percent of all process loops were under direct digital control. The natural emphasis of industry will tend to be on medium-and large-scale applications, but the spread of computer control to smaller applications can be enhanced by a series of demonstration projects in representative industries and processes. A potential benefit is three or more years of increased productivity and reduced energy consumption in hundreds, perhaps thousands, of smaller processing plants that would not occur without the demonstration projects. During FY 1978, a survey will be conducted to determine the current state of utilization of computer control in small plants and an analysis to determine candidate applications will be completed.

• Energy Management of an Integrated (Paper) Plant: This project was initially funded in FY 1977. It is to demonstrate savings in energy and cost per ton of paper produced, using an overall macro-system approach, through computer generation of set-points. A large integrated paper mill will have a number of boilers using both purchased and waste fuels to drive a number of generators and to produce process steam, and in addition, the mill will often purchase some electricity. The number of units on-line is determined by production requirements. This project will determine the efficiencies of the various installed units, their optimal use ranges and their normal availability during FY 1977. In FY 1978, this project will involve design and development of both the necessary hardware and software to generate real-time set points for most energy efficient operation using any number of these options as determined by the scheduled production needs.

• Alternates to Natural Gas in Curing Coil-Coated Material: A PON will be issued in FY 1977 for proposals on the development of non-natural gas systems for curing coil-coating finishes and matching such processes to finishing formulation development. A contractor will be selected and the application surveys and system design effort will be completed in FY 1977. In FY 1978, detailed design and manufacture of demonstration equipment will be performed leading to a demonstration in FY 1979.

• Carbon Monoxide as a Feedstock: This project is the investigation of the chemical aspects and efficiencies of using carbon monoxide (a waste by-product of blast furnaces) as the feedstock (replacing natural gas) in the manufacture of various industrial chemicals and fertilizers. This project will be initiated during FY 1977 during which various catalysts will be investigated to identify techniques to utilize low purity carbon monoxide in normal waste streams; to analyze the process feasibility and economics and to conduct feasibility experiments in the laboratory. Success in these analyses and experiments will lead to further phases of development in FY 1978 and to demonstrations in subsequent funding periods.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
C. Agricultural and Food Process Efficiency.....	B/A	$3,430	$4,800	+$1,370
	B/O	1,975	3,570	+ 1,595

This category is directed at reducing the energy used in producing and processing food and fiber in the U.S. The agricultural production industry is characterized by a large number of small businessmen (farmers) that do not possess the facilities or capital for conducting energy conservation research and development. Likewise, the food processing industry consists of both large and small businesses. The industry is very fragmented and lacks facilities for conducting extensive energy conservation research and development. Both agricultural production and processing industries have large seasonal energy needs that are critical to maintaining a dependable food supply. The following summarizes the projects for this category in FY 1978:

(Dollars in thousands, except whole dollars in narrative material)

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Category Activity:	SYSTEMS AND APPLICATION ANALYSIS	DESIGN AND DEVELOPMENT	DEMONSTRATION AND TECHNOLOGY TRANSFER
FY 1978 Projects:	• Paper Pulp Characterization • Food Packaging and Preservation Alternatives • Irrigation Systems • Heat Pump Grain Drying • Whole Milk Sterilization	• Nitrogen Fertilizer Production • Textile Process Modification • Textile Hyper-Filtration • Poultry Processing Modification	• Headbox for Paper Processes • Foam Fiber Technology • Plate Food Recovery • Mechanical Dewatering in Paper Making

During FY 1976, the Transition Quarter and FY 1977 there were key projects carried through the preliminary studies and analytical phases. Some of these will conclude with study reports such as fruit dehydration processes, irrigation pumping alternatives and thermal energy recycling in fertilizer production. Other projects to be completed through demonstrations in FY 1977 includes meat processing and vacuum blanching. Others continue into FY 1978 and some reach significant hardware demonstration phases in FY 1978 causing the increased funding level shown.

The following briefly describes each of these ongoing programs and those which are new starts for FY 1978:

- Characterization of Paper Pulp: Energy required for the production of paper can be reduced by development of a tool for rapid characterization of both virgin and recycled pulp fiber stocks. During FY 1976 and FY 1977, algorithms for optical imaging characterization of pulp fibers were developed and correlations of optical fiber characteristics and paper quality were developed through laboratory testing. In FY 1978 correlation of optical characteristics of pulp fibers and paper quality will be completed and design data for an optical imaging device in cooperation with instrumentation companies will be generated.

- Poultry Process Modification: A program is to be initiated in FY 1977 to demonstrate technology for reducing energy consumption in the poultry processing industry. Process modifications to reduce consumption of hot water and refrigeration requirements will be developed and demonstrations will be conducted. During 1977 poultry systems analyses will be completed and modifications for saving energy identified. In FY 1978 these process modifications will be demonstrated in a poultry processing plant.

- Textile Process Modification: This includes the analysis of wet finishing processes in textile manufacturing, identification of conservation potentials, definitions of process modifications to conserve energy and conduct of a pilot scale demonstration in a textile plant. In FY 1977 the energy consumption by process step is being determined and the more energy intense processes identified. The energy savings potential is being determined, process modifications are being identified and initial designs are to be started for demonstration equipment. In FY 1978 a pilot demonstration of the improved process equipment will be run in a textile operation and the results will be disseminated by a seminar.

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• Irrigation Systems: The objective of this project, to be initiated by a PON in FY 1977, is the analysis, development and demonstration of crop irrigation systems to conserve energy used in production of irrigated crops including alternative pumping power systems. Successful demonstration will lead to reduced energy for irrigating and a switching from natural gas to more plentiful resources. During FY 1978, the applications analyses will be completed and systems design studies will be performed.

• Heat Pump Crop Drying: This FY 1978 program is directed toward the development and demonstration of heat pump crop drying systems that effectively and economically dry grain and other crops and are viable alternatives to both propane - fired and electrical resistance drying systems. The program will develop both low and high temperature drying equipment, evaluate thermodynamic and economic performance and determine the impact (social, economic, institutional) of heat pump drying. In FY 1978, demonstration of heat pump grain drying using a low-temperature bin dryer will be initiated and completed. Also, in FY 1978, the economic and technical impact of heat pump grain drying will begin and the design and construction of a higher temperature heat pump dryer system started.

• Whole Milk Sterilization Processes: A contract will be awarded during FY 1977 which will initiate studies on the implementation of the whole milk sterilization process. Rigorous test on product taste, storage life and nutrition levels will be conducted so that institutional barriers (state, local and Federal) can be removed to insure adoption of the new process. Methods for attacking consumer resistance to accepting a non-refrigerated milk product from supermarket shelves will be determined. Phase II of the project, to start in FY 1978, will involve commercial demonstration of the process coupled with market testing to insure consumer acceptance of the modified product. A successful program will eliminate refrigeration requirements in the plant after processing, in transit from the plant to the supermarket and in the supermarket.

• Nitrogen Fertilizer Development: This is to develop and demonstrate technology for the reduction of natural gas used in the production of anhydrous ammonia for manufacturing nitrogen fertilizers. Currently about 1% of the U.S. energy consumption is used for producing fertilizers for use in agriculture. Natural gas is used both as a feedstock and as a heat energy source. A Program Opportunity Notice (PON) will be issued during FY 1977 for proposals on developing technology for reducing energy consumption in the production of nitrogen fertilizers. During FY 1978, the feasibility studies will be completed and development of alternatives will be identified.

• Plate Food Recovery: This new project start in FY 1978 is the multiple cost-shared demonstration of equipment which will convert restaurant plate food waste into a feedstock for pet food production thereby saving the energy required to grow and process such pet food by current methods. During FY 1978 demonstration units will be ordered and demonstration restaurants will be selected and installation will begin.

• Mechanical Dewatering: Paper and paperboard are produced from a suspension of fibers in water by forming on a screen (80% moisture), mechanically pressing to remove excess water (60% moisture), followed by evaporation of the remaining water in the sheet. This FY 1978 program will investigate the technical feasibility of mechanically pressing the wet sheet to remove the maximum amount of water preceeding the evaporation process.

CONSERVATION RESEARCH AND DEVELOPMENT
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- Textile Hyper-Filtration: This is a joint ERDA/EPA project directed towards a textile dyeing process in which the hot water and dyestuffs are recovered/reused by high efficiency membrane filters. In FY 1977 the EPA-ERDA project will transition to ERDA, various filtration equipment will be rented and comparatively tested and evaluated. The results will be made available and demonstration equipment selected. In FY 1978 the demonstration equipment will be fabricated and installed preparatory to a full scale demonstration in FY 1979.

- Food Sterilization by Gas Exchange: This is a process by which fresh food is sterilized by evacuating the oxygen and replacing it with another gas and sealing in a thin film package instead of cans. The result is that no heating or cooling is required and packaging materials are saved. During FY 1977 a feasibility study will be completed to determine the process applicability to broad categories of foods, to determine the energy savings potentials and one model of the system will be developed. During FY 1978 a demonstration of a pilot plant will be conducted on a variety of foods in a commercial plant.

- Headbox for Paper: This is the development and demonstration of a more efficient "headbox" (equipment that distributes the water/pulp - slurry - onto a wire screen for water extraction in papermaking). The objective is to increase the fiber/water ratio so that less energy is required to pump and evaporate the water. In FY 1977 the concept feasibility will be tested using a narrow prototype headbox. The efficiency and design parameters for a full size headbox will be designed and fabricated for a full scale demonstration in a papermill in FY 1978.

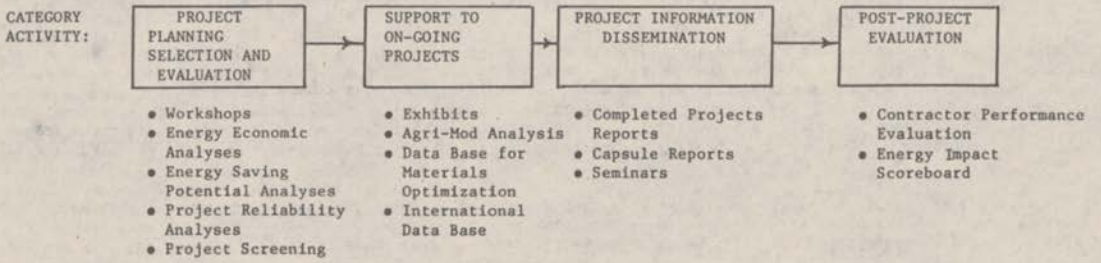
- Foam Fiber Technology: This project is the design, development and demonstration of a process which uses foam as a carrier for dyestuffs in textile dyeing instead of water. This results in the goods leaving the dydbath essentially "dry" therefore greatly reducing the energy required to evaporate the water as in conventional processes. During FY 1977 the analyses will be completed to identify the optimum foam constituents and a prototype (less than full size) is to be designed and tested in a textile plant and initial marketing analyses are to be started. In FY 1978 the plan will be completed and full size units will be designed and fabricated and implementation will be stimulated by dissemination of prototype unit results.

	Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
D. Technology Transfer and Industrial Impact Analysis....B/A	$2,510	$1,210	-$1,300
B/O	2,275	1,120	- 1,155

This category is directed at identifying industrial user needs (through market research) for Federally sponsored research and development in the efficient use of energy and at bringing the results of this sponsored research into the private sector thereby resulting in an increase in the efficiency of industrial energy use and a reduction of energy consumption. The decrease indicated for this category in FY 1978 is a result of a regrouping of activities so as to integrate many of the related technology transfer functions into the specific demonstration projects themselves. Actually, in total, the related activities of this category will be increased in number and effectiveness in FY 1978. The following summarizes the sequences and projects of this category in FY 1978:

(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
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The following paragraphs briefly describe the FY 1978 projects which are comprised of on-going efforts from prior funding periods and selected new project starts for FY 1978:

• Workshops: Emphasis to date has been on "user need" identification of recommendations for Federal research in such areas as agricultural processing, thermal insulation, utilization of waste heat, pulp and paper and agricultural production. FY 1978 workshops will be held on textiles, chemicals, copper and glass and directed toward identifying potential needs and potential projects.

• Energy/Economic Analysis: This new FY 1978 project will assess the relative costs and benefits of alternative and substituting materials by means of total energy accumulations. The significant energy intensive industrial commodities will be analyzed; compatible performance factors identified; laboratory or full scale tests programmed as required; and an implementation program developed to achieve energy reductions through optimum materials uses. During FY 1978 analyses will be completed on industrial materials and performance characteristics.

• Energy Saving Potential Analyses: Many opportunities exist for various forms of industrial research, however, the Division mission being that of research which results in energy savings has surfaced the need for specific energy saving program planning and analysis to occur. Initial analytical work in this area was initiated in FY 1977 and will continue in FY 1978.

• Project Reliability Analysis: This project is a new start in FY 1978 which will provide reliability analysis disciplines to selected industrial projects where project complexity and technical risk warrant it. During FY 1978, surveys of projects will be completed, applicable projects will be identified and the initial analyses will be conducted.

• Project Screening: The Division received numerous proposals from industry, academia and various consulting and engineering groups. This has necessitated the development of a project screening methodology to assist in decision making for project funding. This work started in FY 1976 and will be further refined during FY 1977 and FY 1978.

• Exhibits: In order to assist in the stimulation of market penetration of energy efficient research results, participation in industrial trade shows was selected as one means of communications. Exhibits were designed and introduced in four trade shows in FY 1977 and updates will continue to be designed in FY 1978 as additional research and results become available.

• Project Tracking and Management Information System: This effort was started in FY 1977 and will continue in FY 1978 to provide for project tracking, evaluation and identification of technology transfer opportunities.

• Data Base for Materials Optimization: This project will serve as support for the optimization program. A data base will be assembled from the large but fragmented body of available knowledge of energy factors associated with the flow of commodities through the economy. Incomplete or missing data will be obtained through research as indicated by the energy/economic analyses requirements.

• International Data Base: Since the inception of the Conservation Program there has been an awareness that with foreign energy costs being higher than domestic, international comparisons might provide targets of energy conservation opportunities. Through participation in the Committee on Challenges to a Modern Society Rational Use of Energy Program and the International Energy Agency data contributions have been received from and made to the international community. Comparative reports have been made in cement, steel, polyvinyl chloride, and methodologies. In FY 1977, a joint effort was initiated with the Department of Commerce to identify energy efficient products manufactured in the U.S. for export and identification of foreign technologies that might be of benefit to U.S. industry.

• Completed Projects Reports: As a result of each project funded, final reports with considerable technical data are provided by the contractor. In FY 1978, it is anticipated that there will be a significant increase in printing costs and distribution.

• Capsule Reports/Manuals: As research results become known, a more effective line must be developed between researcher and user. Technology transfer products developed to date consist of a series of executive briefing reports, technology applications manuals, etc., on such topics as evaporators, opportunities for industrial energy conservation

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through computer control, efficient operation of slot forge furnaces, air-fuel ratio control, energy-saving paint systems, improving the efficiency of industrial dryers, etc. As additional data becomes available in FY 1978, additional reports will be developed.

- Seminars: Another "output" mechanism for dissemination of research results is that of providing seminars on research in progress or research results to identified users in order to facilitate market penetration. In FY 1977 a minimal effort was initiated which will be expanded in FY 1978.

- Contractor Performance Evaluation: With the numerous projects and contractors currently being funded, a means to evaluate contractor performance has become a necessity. This will be a new start for FY 1978.

- Energy Impact Scoreboard: This activity will be initiated in FY 1978 and will consist of a continuing communications link with the technologies implementations related to projects funded by Industrial Energy Conservation, to maintain a running scoreboard of data reflecting degree of market penetration with time including number and size of equipment installed, dates, locations, etc. The FY 1978 activities will be the development of procedures and the list of contacts for each Industrial Energy Conservation project and determining the results to date.

- Agri-Mod: This project was initiated in FY 1977 to extend the capability of an existing agricultural sector computer simulation model so as to examine energy requirements in greater detail. In FY 1977, the model was properly revised and in FY 1978 it will be applied to the agricultural sector to identify, measure and locate effects of and needs for new technology.

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CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
2. Buildings and Community Systems	B/A	$26,600	$52,000	+$25,400
	B/O	22,610	42,800	+ 20,190

Category	Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual Transition Quarter B/A	Actual Transition Quarter Obs.	Actual Transition Quarter B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
A. Buildings Design and Structure	$ 4,750	$ 4,173	$1,469	$1,250	$1,515	$1,520	$11,280	$11,280	$ 9,160	$19,000	$15,580
B. Community Energy Utilization	2,600	2,224	920	775	1,022	1,490	5,945	5,945	5,450	14,750	13,600
C. Urban Waste	1,079	2,202	594	750	1,889	1,397	4,450	4,450	3,700	7,500	6,000
D. Technology and Consumer Products	2,043	1,289	449	650	1,670	1,142	3,905	3,905	3,425	7,570	5,070
E. Consumer Motivation and Behavior	0	0	0	0	0	0	395	395	375	980	750
F. Economic Analysis and Technology Transfer	1,050	856	490	316	425	444	625	625	500	2,200	1,800
Total Buildings and Community Systems	$11,522	$10,744	$3,922	$3,741	$6,521	$5,993	$26,600	$26,600	$22,610	$52,000	$42,800

Objectives: The subprogram is formulated around increasing energy utilization efficiency, providing for options to substitute energy forms such as coal for natural gas, and for providing technologies which decrease the need for energy to satisfy human needs. All activities undertaken are directed at providing these new technologies within a framework that is both economically and environmentally sound.
The subprogram objectives are further enhanced by the necessity to complement private sector efforts, foster acceptance of energy saving technology, maximize the effectiveness of energy use and to minimize adverse socio-economic and/or environmental impacts.

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CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

Thirty two (32) percent of all energy consumed in the United States is consumed by the buildings sector. Translated into physical terms, that is equivalent to a consumption of almost 12,500,000 barrels per day equivalent (BPDE) of fuel oil. The major objective of the Buildings and Community Systems subprogram is to significantly reduce those consumption figures without affecting the standard of living; that is to say, the ERDA program is directed at increased efficiency of energy utilization in the built environment as contrasted to a regulatory function of curtailment.

The subprogram is directed at a reduction of 2,400,000 BPDE by 1985 and at least 4,100,000 BPDE by the year 2000. The objective here is to aid in the widespread utilization of alternate energy sources (e.g., solar energy for the heating and cooling of buildings) thereby further reducing the consumption of currently used non-renewable resources by 12 percent by the turn of the century. The strategy for attaining stipulated goals is to: (1) encourage and support the installation of energy efficient technologies as soon as possible; (2) develop and commercialize systems which will reduce the dependence on petroleum and natural gas; and, (3) develop and disseminate information about new technologies concerning energy efficiency utilization improvements.

In undertaking the Buildings and Community Systems RD&D subprogram, various management procedures and tools have been developed and utilized to insure that the RD&D activities will lead to economically and technically viable end products which will fill a need and be used by the maximum segments of our society. For example, prior to being initiated, each project is evaluated against certain "threshold criteria." This entails examining the activity from a cost/benefit viewpoint.

Another important objective is to involve non-Federal government groups with research, development and demonstration activities to expedite the transfer of technology and data to potential users as soon as the technical and economic feasibility has been validated. A majority of the funds expended in the Buildings and Community Systems area are spent with industry in support of a large degree of cost sharing. In addition to the direct RD&D ERDA/industry relationships, this subprogram works closely with various trade and non-Federal organizations and derives input from many sources in this manner. Included in the list are: (1) on the state level, the National Governors Conference and the National Conference of States on Building Codes and Standards; (2) on the local level, the League of Cities and Public Technology, Inc.; (3) National Association of Home Builders; (4) American Institute of Architects; (5) National Electric Manufacturers Association; (6) the Edison Electric Institute; (7) the American Gas Association; and, (8) American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

For clarity, the subprogram is described under several separate designates, such as "Commercial Buildings," "Residential Buildings," etc., but in actuality the activities undertaken all form a part of an integrated effort directed at achieving stated goals and objectives. The subprogram is pursued in its entirety at all times, since the elimination of any one project would have a negative impact on all other elements of the program. For example, all activities which have been undertaken

under those termed "Commercial Buildings: or "Residential Buildings" have been providing the foundation for the development of energy efficiency standards for new buildings.

Federal Role: ERDA's RD&D work will help provide options for the rational use of energy in the built environment in support of user Federal agencies, state and local governments, various sectors of the buildings industry, and the individual consumer. Federal involvement is necessary because of the following special considerations inhibiting progress in this sector:

- The fragmentation of the buildings industry, which makes it difficult to aggregate research funds to promote energy efficiency in the total built environment.
- Financial constraints, which presently encourage buyers to base purchase decisions on initial costs, rather than life cycle costs.
- A complex regulatory system (building codes, zoning restrictions, tax authorities) which inhibits rapid change.
- Industry's belief that energy-efficient components which do not provide a new service will not yield sufficient economic return.
- The difficulty of convincing the individual of the "additive" effects of energy-related decisions and their potential impact on society.

The objective of the 'near term' is to reduce unit energy consumption by 1980 for an immediate savings equivalent to 800,000 BPDE; to lower unit energy consumption in existing buildings and community systems by 20 percent and in new buildings and community systems by 30 percent by 1985.

In the mid to long term significant savings can be made by design of buildings and community systems that are energy efficient. Existing buildings, 70,000,000 dwelling units and approximately 24,000,000,000 square feet of commercial space continue to consume energy, generally very inefficiently since they were designed and constructed in an era of cheap and plentiful fuel. Owners occupants and operators of such buildings, have different objectives regarding return on investment. Their objectives do not necessarily coincide with energy conserving measures and are typically in the position of adopting competing uses for limited capital.

CONSERVATION RESEARCH AND DEVELOPMENT
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National goals have been established for reduced energy consumption in the buildings sector. P.L. 94-385, Title III mandates the development and promulgation at the Federal level of minimum energy efficiency standards for all new buildings to be constructed in the United States. Prior to enactment, many states have moved in the direction of implementing each standard. ERDA will provide impetus for and undertake those research, proof-of-concept experiments and evaluation activities leading to support promulgation and uniform energy performance standards for voluntary and/or mandatory adoption by state and local governments and to bring forth technical options for meeting such strategies. The Federal role will provide leadership to properly consider life cycle costing. Federal activities will assist in overcoming the institutional barriers by improving utilization efficiency in the areas of new community forms, land use planning, on-site total energy and integrated utility systems. ERDA will provide a focus for the development of materials, processes, methods, equipment, etc., to obtain this reduction in energy consumption.

Accomplishments:

- In support of HUD, major RD&D activities continued to develop performance standards for buildings. One of the most significant elements this year was the development of a model code for energy for buildings which is based on the private sector standard ASHRAE 90-75 and which was jointly developed by the existing model code organizations.

- Residential demonstrations, in two locations, of ACES were completed, and an office building demonstration site is being selected. Planning for a central community ACES is in process.

- Retrofit of thermostatic valves was accomplished in 1000 rooms of a multi-family development and a complete evaluation of their performance is underway.

- The restaurant energy efficiency demonstration project is being completed and the program is being transitioned to management and co-funding by the New York State ERDA for continued experimentation with advanced systems.

- Evaluation of other demonstrations is nearing completion (Jersey City municipal buildings, minimum energy dwellings, Twin Rivers, etc.) and a research agenda established.

- Identification of financial and institutional barriers to energy conservation measures in new and existing buildings is being completed.

- Six feasibility analyses for grid-connected combined heat/power plants are in process.

CONSERVATION RESEARCH AND DEVELOPMENT
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- The initial phase of the joint ERDA-HUD effort for the development of organizational strategies for growth management of communities impacted by energy development (supply or use) has been completed and a demonstration is being planned.
- A bilateral international agreement has been consumated with Greece for addition of the energy parameter to the Ekistic model for community development.
- Data collection is being continued on the joint U.S.-German project for central heat pump community systems.
- The Clarksburg Community Energy Conservation program was completed and national implementation strategies developed.
- In conjunction with EPA, a national RD&D plan for urban waste/energy programs has been developed.
- An innovative risk acceptance package has been developed for the Seattle project.
- The ANFLOW (upflow anaerobic digester) was successfully operated on a laboratory scale.
- The screw-in fluorescent light bulb was brought to an advanced stage of development.
- The water heater retrofit kit was tested and marketing was initiated.
- Various approaches to group incentive/participatory decision making for energy conservation in master metered buildings are being tested and evaluated.
- A major demonstration is being conducted in Denver to introduce the life cycle cost concept to homeowners.
- Threshold Evaluation System as an evaluation tool for screening and ranking projects was developed and implemented.
- Two pilot outreach projects, establishing the base for technology transfer activities have been completed.
- Specific international projects for information exchange of thermal characteristics of buildings, heat pumps, etc., are in operation.

These accomplishments are the result of RD&D performed under the following major thrusts:

- Buildings Design and Structure: Works with entire buildings industry to undertake activities necessary to develop and commercialize energy efficient materials systems, standards, for retrofit/new construction.

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

- Community Energy Utilization: Determine the community forms and development patterns most amenable to employment of integrated systems and community design, including urban waste technology.

- Technology and Consumer Products: Identify technology opportunities for improved performance of consumer products; integrated function includes consumer motiviation and behavior studies.

- Technology Dissemination and Transfer: Presentation of results will include manuals and guidelines for use by all segments of buildings industry.

Budget Request:

The FY 1978 request for $52,000,000 in budget authority is an increase of $25,400,000 from FY 1977. Operating costs of $42,800,000 is an increase of $20,190,000 from FY 1977.

The program is balanced between efforts which start to accumulate savings in the near term (architectural and engineering systems, and consumer products) and mid term (community systems, urban waste, and technology development). The program will move from feasibility studies to demonstration where appropriate energy data will be developed to overcome the institutional resistance to energy conservation efforts. Technological innovations designed to decrease energy consumption cannot be expected to achieve a significant impact unless the impediments are minimized.

The budget request for each of the subprogram categories is shown in the following along with project descriptions:

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
A. Buildings Design and Structure	B/A	$11,280	$19,000	+$7,720
	B/O	9,160	15,580	+ 6,420

This area of involvement is aimed at increasing the efficiency of energy utilization in commercial and residential buildings. The present inventory of commercial space is 24 billion square feet and in the year 1985, 30-40 percent of the inventory then in place will have been constructed in the previous decade.

Projects in this area are concerned with energy conservation in residential buildings, office buildings, hospitals, schools, food stores, and municipal buildings. To overcome present constraints resulting from the fragmentation that is characteristic of the building industry, there will be special efforts to develop new institutional mechanisms, such as 'partnerships' of utility companies and savings and loan organizations designed to assist private industry in undertaking innovative energy conservation measures.

(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

- Commercial Buildings

This area of involvement is aimed at increasing the efficiency of energy utilization in commercial or non-residential buildings and emphasis will continue to be placed on energy conservation measures in both the existing and future stock of buildings.

Projects in this area are concerned with energy conservation in office buildings, hospitals, schools, food stores, and municipal buildings. To overcome present constraints resulting from the fragmentation that is characteristic of the building industry, there will be special efforts to develop new institutional mechanisms, such as 'partnerships' of utility companies and savings and loan organizations designed to assist private industry in undertaking innovative energy conservation measures.

The analysis of energy use patterns for office buildings completed in FY 1977, was based upon the initial survey of 900 buildings in New York City, representing different structural types in this sector. Studies of these selected buildings resulted in retrofitting options which would be most cost effective. In FY 1978, these retrofits will be demonstrated and the results will be disseminated nationwide to designers, owners, contractors, etc.

On the basis of investigations in prior years of energy consumed in the production and transportation of buildings materials and their assembly at the building site, a catalog of energy units associated with different building materials and structures will be completed in FY 1978 for use by designers and building owners to determine optimum energy utilization.

A retrofit demonstration of four selected municipal buildings in Jersey City, New Jersey, was initiated in FY 1976 and evaluated in terms of energy conservation and savings in operational costs in FY 1977. The results will be completed in FY 1978 and disseminated to other local government entities through the Urban Technology Agent System (funded by the National Science Foundation) and its twenty-seven members.

The studies of energy use patterns in hospitals initiated by FY 1977 in cooperation with HEW, VA, DOD and major private groups in the field, has been concerned with filling the void in fundamental scientific data that have caused such buildings to be over designed and operated so as to consume excessive levels of energy.

A potential for reduced energy consumption in commercial buildings and in large multifamily buildings is through the use of fuel cell total-energy systems. The technology development is being pursued by CONRT (Division of Conservation Research and Development). In FY 1978, the buildings program will do appropriate feasibility and systems studies leading to demonstrations in appropriate facilities.

CONSERVATION RESEARCH AND DEVELOPMENT
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During FY 1977, simulation studies were undertaken to establish basic data in the relationships of building design mechanical equipment, as well as the operations and maintenance of supermarkets. In FY 1978, field validations will be undertaken as a result of test simulations, with actual installations of hardware projecting the best energy conservation potential with the most cost effective measures possible.

Inasmuch as schools consume about 10 percent of the total energy used in all commercial buildings, special RD&D efforts will be undertaken in this subject area to demonstrate energy saving applications.

At the end of FY 1976, GSA placed into operation a general purpose office building in New Hampshire designed from the onset as an energy efficient building with multiple systems incorporated to allow for 'side-by-side' comparisons. Systems such as task lighting were funded for in part by ERDA. In addition, the evaluation program is being carried out for ERDA by NBS. In FY 1978, in addition to continuing systems evaluation, data gathered during FY 1977 will be packaged and disseminated to the private sector.

- Residential Buildings

This area of involvement is concerned with increasing the efficiency of energy utilization in residential buildings which now total over 70 million dwelling units. Over 30 percent of the housing units are estimated to be in place in 1985 as a result of new construction and retirement of older structures in the previous decade; the research and development programs in this subject area will significantly impact both existing and yet-to-be constructed housing.

As a result of significant progress with ACES, commencing with the demonstration houses started in FY 1976, there will be further expansions of the new technology to other types of buildings. This system extracts heat from an insulated tank of water to warm a building, and provides hot water. As the heat is extracted from the tank of water, it becomes a mixture of ice and water; used as a cooling source during the summer season. In FY 1978, this concept will be applied to office buildings, commencing with a pilot project to be conducted by the technical arm of the Sourthern Conference of Governors.

Projects in the area are concerned with all types of housing, from single family detached dwellings to high-rise, multi-family buildings. To assist property owners, research, development and demonstration projects are aimed at improved building designs and mechanical equipment. In addition, there are efforts to develop institutional mechanisms to encourage homeowners to make the necessary investment to achieve maximum energy conservation.

In FY 1978, ERDA will undertake new programs to reduce energy consumption in existing multi-family buildings. Included in this program will be research development and demonstration programs conducted in cooperation with HUD and state and local housing authorities.

CONSERVATION RESEARCH AND DEVELOPMENT
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During FY 1978, the demonstraton of new technology will be conducted on waste heat utilization. Much energy is wasted in all building types by exhaust fans, vent hoods, combustion stacks, dryer vents, plumbing stacks and other mechanical devices. The objectives of this program are: (1) to transform consumption patterns to improve energy utilization; (2) protect and enhance the general health, safety, welfare and environment related to energy; and (3) to perform basic and supporting research and technical services related to energy.

During FY 1978, research and development will be conducted towards the commercialization of new technology developed under ERDA's Energy Storage Systems subprogram. New forms of thermal storage within structural elements of buildings, including phase-change chemical elements, will be tested and demonstrated for subsequent infusion into the building industry.

In FY 1978, looking forward toward the long range effort, we must develop innovations in the basic designs of housing.

Solutions will be sought for new ideas on residential shelter with dramatic savings in energy.

The results of this effort will consist of design guidelines which will be disseminated to architects and engineers and others contemplating new construction or major renovations.

- Performance Standards

One of the most promising undertakings begun in FY 1976 has established precedents in codes and standards. The lack of uniform standards in state and local building codes has been a major stumbling block, adversely affecting new building technologies for many generations.

Energy savings were realized starting in FY 1977 as a result of the activities initiated in the Performance Standards area. Some of the standards related activities are included in the following:

- An effort was undertaken with a consortium of all the major model code organizations to establish a model training program for state and local code groups.

- An analytical technique in the public domain to be used by small business as well as code officials in connection with use of energy efficiency standards was developed and promulgated.

- Development of performance standards which permit the greatest design latitude, move forward to meet the requirements of Presidential initiatives and Congressional mandates.

CONSERVATION RESEARCH AND DEVELOPMENT
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Under a contract executed between ERDA and the National Conference of States on Buildings Codes and Standards there is being developed a single model energy conservation code, based upon ASHRAE 90-75 standards, which will be applicable to all new buildings and will be compatible in language and application with building codes now administered at the state and local levels throughout the country. Among the other code groups participating in this precedent setting endeavor will be the International Conference of Building Officials, the Southern Building Code Congress, the Building Officials and Code Administrators International and the National Academy of Code Admministrators.

In FY 1978, research and development of performance standards will be continued on a design of more economical, energy efficient buildings than is possible under currently accepted standards. This program was initiated in FY 1977 under an Administrative and Congressional mandate calling for the promulgation of such standards within three years.

For example, in developing performance standards for the different building types it has been essential to determine the requirements and patterns of energy consumption that are characteristic of each building type in the different climatic regions of the country. Critical research has also been necessary in such areas as indoor air quality, thermal comfort, illumination, ventilation requirements for health, and part load efficiencies of mechanical systems.

Analytical techniques ranging from economic models to those required for determining the impact of standards on building costs, construction practices, and the institutional mechanisms will be developed in this program. Feasibility experiments will be conducted to evaluate the effects of energy conservation technologies and standards in differing climatic regions. Another major thrust will be to undertake in cooperation with the cognizant private sector organizations (such as ASHRAE) the development of energy efficiency standards for existing buildings undergoing modifications.

The objectives of the performance standards program are: (1) to increase utilization of essentially inexhaustible domestic resources; (2) to transform consumption patterns to improve energy utilization; and (3) protect and enhance the general health, safety, welfare and environment related to energy.

Strategies required for the performance standards are: (1) encourage and support the installation of energy efficient existing technologies as soon as possible; and (2) develop and translate Federal sector new energy efficient technologies and appropriate institutional improvements. These are to be done in cooperation with other Federal agencies, particularly HUD and FEA, state and local government and private sector.

CONSERVATION RESEARCH AND DEVELOPMENT
END-USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
B. Community Energy Utilization	B/A	$5,945	$14,750	+$8,805
	B/O	5,450	13,600	+ 8,150

Buildings, and the people that occupy them function together in a community, and the forming of that community and/or the interrelationships between the elements of the community afford new opportunities for energy savings without curtailment or regulation. For example, by examining the utility functions needed to maintain a society, electric energy for lighting and appliances, thermal energy for space conditioning; waste collection and disposal; and potable water supply, it is seen that there are numerous opportunities to combine (integrate) these functions with benefits of energy savings together with reduced environmental impacts and cost reductions. If we also study community form, information can be made available to local decision makers which will help to achieve on the local level, planning and zoning which allows for the goals and objectives of the community to be met at a lower input in energy.

The Community Systems area has been subdivided for convenience into three categories of activities: Integrated Systems, Community Design, and Commercialization.

The activities being undertaken in the community subprogram rely on technical developments produced elsewhere, as well as on unique R&D activity in the subprogram. Agreements have been developed with those ERDA organizations concerned with developing technologies to utilize solar, geothermal, coal, and nuclear sources. This program will increase by $8,805,000 in budget authority in FY 1978. This is a result of projects moving from the research phase into development and demonstration. Specific projects are discussed below.

- Integrated Community Energy Systems (ICES)

The activity related with the development and demonstration of Integrated Community Energy Systems is a major element of the Community Systems area within the Buildings and Community Systems subprogram. The main objective of this activity is to produce the systems which will satisfy the energy needs of a community while conserving energy and imported fuels, minimize adverse environmental impacts and offer economically attractive utility rates to the consumer. The initial effort in this activity during FY 1976 and FY 1977 has been concentrated in developing the design and analytical tools that are necessary for the synthesis, feasibility analysis and design of such systems. Starting in FY 1977 and continuing in FY 1978 specific site applications of various ICES (e.g., ICES-USA) will be processed utilizing the previously developed tools.

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- Advanced Technology Mix Energy Systems (ATMES)

The goal is to develop an on-going program of energy systems engineering development for Communities for taking advantage of technological advanced R&D activities within and outside ERDA and providing systems to optimum configuration and performance.

In FY 1976 and FY 1977, the ground work was completed and the mechanism established to accept and process any and all RD&D results of the various ERDA specific technology programs and other on-going program activities. The basic tools have been developed to assess the significance of these RD&D results to Integrated Community Energy Systems. In FY 1978 the tools for synthesis and feasibility of ATMES will be developed. The effort undertaken by this element is translating RD&D efforts into practical and usable Integrated Community Energy System with significant effect on the intermediate and long range energy conservation and scarce fuel substitution goals of the program activity.

- Grid-Connected System

The goal is to develop a system which always operates at the highest possible energy efficiency by relying on the local grid to act as an electrical flywheel. In FY 1976 and FY 1977 a feasibility analysis and several site specific designs were completed. In FY 1978 the development of the demonstration system will be undertaken with expected completion during 1979. ERDA's participation in the demonstration will be for overcost only. This will cover the expense for energy conserving subsystems of a high risk/reward ratio project that would not otherwise be attempted by the private sector.

- Coal Using System

This activity leans heavily on work accomplished under ATMES and under the ERDA Fossil Fuel Energy (F.E.) program. The goal is to develop coal using systems on a community level and replace oil and gas as primary fuels for the satisfaction of the community energy needs. In FY 1976 and FY 1977 the tools for systems synthesis, feasibility analysis and design were developed and computerized. In FY 1978 these tools will be utilized to develop a site specific coal using system for development, demonstration and evaluation in subsequent years. ERDA's participation for analysis and design is major since the development of the tools and the demonstration of the systems are major incentives for widespread adoption of coal using systems. Georgetown University has been awarded a contract by F.E. for the demonstration of a fluidized bed combustion system. In FY 1978, design of a district heating/cooling, building-control system in conjunction with the fluidized bed project will be undertaken. Construction and evaluation will be initiated in subsequent fiscal periods.

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- District Heating and Cooling Systems

The goal of this project is to develop District Heating and Cooling Systems which will have a higher energy efficiency, an improved operation and maintenance and a better environmental impact than the existing comparable systems. In FY 1977 an analysis was completed of the various subsystems, their impact on overall performance and ways of optimization for each subsystem. In FY 1978 site specific feasibility analysis and design of a new system for major retrofit of an existing system will be undertaken with development and demonstration following in subsequent years. Tools and techniques developed by ATMES and Coal Using Integrated Community Energy System will be utilized for this work. In undertaking these activities a close working relationship has been established with the International District Heating Association. Furthermore, the program foundation in part rests on extensive European experience being transferred through our activities with the International Energy Agency. In effect the nuclear group examines the potential and impact on plant design for widespread implementation of district heating schemes. The communities systems activity "picks up at the city gate" and works within the community setting pass requirements to the power plants.

- Alternate Fuel ICES

The goal of this project is to develop ICES which would minimize use of depletable fuels such as coal, oil and gas by utilizing to the maximum feasible extent solar, wind and geothermal energies and solid and liquid waste derived energies as primary inputs to the system. These systems will be developed in close coordination with the single technology RD&D programs within ERDA such as the Solar Total Energy Program managed by Sandia Laboratory and the Urban Waste Technology Program of Conservation. Innovative systems of built-up heat pumps utilizing natural heat sinks and direct cooling from natural cold water reservoirs are candidates for consideration for these systems. In FY 1978 the feasibility analysis and conceptual design of three or more sites will be performed.

- Power Plant Retrofit to Integrated Community Energy Systems

The goal of this project is to pave the way towards large scale application of integrated systems and adoption of the concept as a viable alternative to wasteful power plants by the power companies and the utility industry in general. In FY 1977, a site specific analysis and design has been performed on an existing power plant and in FY 1978, the implementation of this design will be undertaken with an expected completion in FY 1979. ERDA's participation will be for overcost covering institutional and monitoring systems and energy conserving systems of high risk/reward ratio which would not be assumed by the private sector.

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- Community Design

The initial priorities of the Community Design technical areas have been the systematic development of both a quantitative understanding of the relationship between end use energy consumption and the physical characteristics of the community. More specifically this work has involved collection and analysis of relevant data to determine the importance of non-technological factors, more energy efficient community design concepts and a process or methodology whereby energy conservation considerations could be incorporated into the community development process and assessed against financial, social and environmental considerations.

In FY 1978, this category will move toward a direct application of the previous year's research efforts in order to test, refine and when appropriate, demonstrate the energy efficiency of design concepts. Through the selective application of these principles, it will be possible to test the technical, economical and institutional feasibility of community design concepts and obtain measurement of potential energy savings. The continuation of the community energy modeling and master planning activities will serve to meet the growing and increasingly vocal demands for more specific information and guidelines to direct community development activities in concert with energy conservation.

The following project areas define the stipulated goals within the projects of the FY 1978 effort.

- Ekistic Energy Community Model

The goal of the ekistic energy community model is to develop an analytical tool which can be used to define and optimize the appropriate service areas and composition for community energy systems for development of ideal concepts and site specific projects for community design or design modification. During FY 1977 with support from HUD, extensive progress was made in both the collection and analysis of data dealing with the relationship between community energy usage and community design. In FY 1978 the model will be advanced to the stage in order to initiate matching and optimization of integrated systems technology with development patterns.

- Energy Master Planning for New Development

Energy Master Planning activities were initiated during 1977 as a complement to the analytical activities of model development and land use studies. Through ERDA support of case studies of energy master planning for development projects it was possible to assess to what extent innovative master planning can incorporate energy considerations. Continuation of these efforts in FY 1978 (to be conducted in coordination with testing, refinement and demonstration of the ekistic energy community model) will provide the program with site specific development situations for testing concepts.

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- Land Use and Energy

The objective of this work is to systematically assess and develop an understanding of the relationship between end use energy consumption and the physical characteristics of the community as affected by the land use planning mechanism. During FY 1977 research efforts focused on quantification and qualification of land use/energy utilization relationships. Activities during FY 1978 will include the refinement of generalized land use/energy utilization principles developed in FY 1977.

- Urban Laboratories

In FY 1977, a feasibility analysis was undertaken to determine the usefullness of a single, very large residential complex for meeting the RD&D objectives of energy conservation in the built environment. It was concluded that there were indeed benefits to be gained in the overall program in utilizing the existing complex as an "Urban Laboratory." The work on individual buildings is being undertaken under the Building Design and Structures subprogram. Under the Community Energy Utilization area a long range effort, in cooperation with the Urban Waste subprogram area, will be initiated to develop innovative energy supply systems and strategies which can be evaluated and rapidly transferred to the numerous multifamily developments throughout the U.S.

- Community Subsystems Evaluation, Telecommunications

The objective of this project is to assess the energy conservation possibilities of telecommunications and to identify opportunities for application of telecommunication systems in the community. During FY 1977, efforts were initiated to investigate current trends in telecommunications technology and systems with the intent of focusing on the most promising for either saving energy or substitution for energy intensive services and systems. During FY 1978, research will focus on two or three of the most promising telecommunications systems which could be integrated into on-going community energy systems activity.

- Comprehensive Community Planning (Demonstration)

The product of this effort will be a ready-to-use and complete set of technical and institutional guidelines and methods, valid and relevant factual information/data, and example inputs, procedures and outputs, constituting an approach adaptable to existing communities of any size or type found in the United States, for development, implementation and management of an energy plan by local governments.

In FY 1977, a complete set of guidelines, methods, data, input, and procedures were developed suitable for universal adaptation. This methodology was tested using two site specific test cities. In FY 1978, demonstration of this methodology for development of comprehensive energy management plans in a number of US cities will be applied.

- Commercialization

It is the objective of the commercialization area to provide the data and the development (through RD&D) of a strategy which can enhance the adoption of energy conserving community designs and systems that satisfy the energy needs of a community. This is to be accomplished by providing to local decision makers, information about design options which have been proven through the RD&D effort and which will assist those segments of society concerned with the procedure to modify traditional practices established during the era of low cost, nonlimited energy.

FY 1978 reflects the development of mechanisms to assist Public Utility Regulatory Commissions in developing new procedures directed at promulgating regulation in the public interest under the relatively new conditions of high-cost, low-availability energy supply, and to initiate a program to develop the necessary mechanisms for man/systems interface for operation, maintenance, and management of integrated systems. From the analysis, proposals for implementation by public regulatory bodies will be developed. These would allow for modification of policies, rules, decisions, etc., that currently place ICES at a disadvantage to conventional systems. Improved procedures for determination of future energy costs and other parameters associated with economic (cost/benefit) analysis will be developed. Cost sharing will be provided for selective documentation of the processes required to implement ICES on a site where a specific demonstration was identified and evaluated previously.

In undertaking all RD&D activities in this subprogram area, the expertise of other Federal and non-Federal agencies and organizations is actively sought. For example, working relationships have been established with the Federal Power Commission and the National Association of Regulatory Utilities Commissioners.

Institutional Impediments to Energy Conserving Community Design and Planning

- Impact of Public Utilities Regulation

The nature of the regulatory process is such that the initiatives required can only be provided at the Federal level. This FY 1978 effort is a continuation of efforts begun in FY 1977 where an analysis was made of the varying regulatory processes and the impact on these systems.

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- Evaluation of Costing and Economic Analysis as Applied to ICES

  Since the decision in implementation of ICES will always be impacted by economics, it is necessary to evaluate the process and methods to establish appropriate ground rules for cost allocation and cost comparisons with reference to traditional utility costing practices.

  In FY 1977, methods of economic analysis were reviewed and the impact of each on various ICES operating systems was documented. In FY 1978, refined methods of cost projections of energy and improved procedures to evaluate and quantify benefits and costs of ICES will be developed.

- New Initiatives in Community Energy Supply, Conversion, and Delivery System (Workshop Conference)

  The successful adoption of the ICES concept of linking community design and operating energy systems requires close cooperation between various players in the development and operating systems arena. The workshop conference best satisfies this need. It is expected that two (2) such sessions will be sponsored during FY 1978. One session was sponsored in FY 1977. The procedures of these sessions will constitute a major method of technology transfer of Community Systems RD&D.

Market Analysis/Market Share Objectives

- Action Plan for Private Sector Adoption of ICES

  This effort is designed to critically review those areas that impact upon the adoption of the ICES concept by private utility/energy companies to outline a coherent plan to open the door to private industry to participate in development and operation of integrated systems.

  In FY 1977, initial work started on this project. An outline of issues was developed and the investor owned utility community was surveyed. In FY 1978, step-by-step procedures will be developed and a consensus obtained as to the best path for successful implementation of the phase plan of action, and as to the associated benefits expected to be accrued.

- ICES Targets of Opportunities: 1980-1985

  This task, initiated in FY 1977, is designed to survey the developments planned for construction in the FY 1980-85 timeframe and document the proposed physical, social, and economic makeup of these developments. From this data, initial evaluation of the feasibility of providing integrated Community Energy Systems were determined. In FY 1978,

(Dollars in thousands, except whole dollars in narrative material)

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cost sharing will be provided to those selected projects for demonstration of ICES. ERDA will track the planning process, document each stage and recommend and/or coordinate actions to obtain the necessary approvals for implememtation.

- Man/Systems Optimization in Management, Operation, and Maintenance of Integrated Community Systems

Since the ICES concepts have been developed by ERDA, and since man forms an integral and critical part of these systems, ERDA must take the initiative in this project to develop the human management and capabilities which successfully interface man and systems in order to succeed in widespread adoption of ICES.

This is a major effort undertaken by ERDA to develop the mechanisms that will generate the systems and their supportive manpower necessary for the management, operation, and maintenance of integrated community systems. A comprehensive national plan will be developed for the development of the mechanisms necessary to produce the qualified manpower that will be needed for the successful operation of the new systems.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
C. Urban Waste	B/A	$4,450	$7,500	+ $3,050
	B/O	3,700	6,000	+ 2,300

In this category, the objective is to conduct research, development, and demonstration to provide technological options to waste management/waste utilization planners in order that they may select a waste-to-energy system applicable to their specific situation. It is important to provide these options to stimulate the widest possible implementation of systems and achieve significant displacement of fossil energy by energy derived from wastes. If these options are not developed, implementation will tend to be constrained to waterwall incineration. If other options are developed, cofiring of utility boilers with coal and the fuel fraction derived from the material separation of waste could be implemented. Development of added systems, and the solution of economic, technical (corrosion, air pollution), energy and product marketing problems will permit the utilization of materials now wasted.

As part of the implementation of an interagency agreement between EPA and ERDA, a national plan for urban waste is being developed. The described projects indicate those projects to be performed by ERDA. The program is broad based and is designed to provide and use options that directly or indirectly displace fossil fuels. In outline, the combustion techniques formally developed will produce heat for process or district use of the generation of electricity. Pyrolysis techniques produce fuels to supplement or displace fossil fuels in combustion techniques as well as to provide a chemical

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feedstock for ammonia, methanol, or methane production thus displacing or substituting for natural gas. The biochemical conversion techniques are least optimized for energy production but hold promise to provide methane for combustion techniques or direct substitution as well as solid fuels, alcohols, and other energy intensive chemicals.

In FY 1976, several efforts were initiated in the general areas of pyrolysis and biological/biochemical conversion of wastes and one project to investigate the displacement of natural gas by combustion of wastes in a cement kiln. Examples of key accomplishments in FY 1976 included: completion of the design for a 50-100 ton per day plant to produce methane from urban wastes by anaerobic digestion, completion of the design and start of installation of a pilot chemical train to test the use of the gases from pyrolysis of waste as a feedstock to make ammonia (displacing natural gas); a five-fold increase in the rate of production of glucose from wastes by enzymatic hydrolysis. These were continued in FY 1977.

In addition, a limited number of projects will be initiated in FY 1978 to include: investigation and development of one or more selected small-scale systems, initiation of a selected pyrolysis demonstration, evaluation of steam reforming as a conversion process, and work on solution of corrosion problems in waterwall incinerators and boilers fired with wastes and fossil fuels in combination. Many of these will be joint projects involving contributory efforts by industry and local governments. All efforts will be coordinated with EPA.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
D. Technology and Consumer Products.....	B/A	$3,905	$7,570	+ $3,665
	B/O	3,425	5,070	+ 1,645

The objective of this category is to conduct RD&D activities on new technologies in support of the other category elements; to undertake RD&D for energy efficient and cost effective appliances, lighting systems, control systems, heating, cooling and ventilating systems.

During FY's 1976 and 1977, key programs were initiated which will enter advanced stages of analysis, development and/or demonstration in FY 1978. These programs which were begun in prior budget periods, will be carried on in FY 1978.

- Integrated Appliances
  There are many situations where heat rejected by one appliance can be used effectively to reduce the energy required for the operation of another appliance.

During FY 1976, potential energy savings were evaluated and technical opportunities were identified for promising integrated appliance combinations and designs. Additionally, promising applications for integrated appliances were identified and the institutional barriers to acceptance of new energy saving integrated appliance technology were investigated. For example, mobile homes account for a large number of residential housing units being manufactured today, about 400,000 units per year. Conventional practice is to provide mobile homes complete with installed appliances, so this market is an extremely promising one for integrated appliances.

In FY 1977, a demonstration of promising integrated appliance technology was conducted and the results of the demonstration used to evaluate the actual energy and economic impact that full-scale implementation would have. In FY 1978, the demonstration will be concluded and a commercialization plan will be completed.

- Residential and Commercial Applicances

In FY 1977, technical opportunities for increasing appliance efficiency, including improved controls, motors and compressors, heat exchangers, etc., were identified. In FY 1978, evaluation of the potential for application of available and new technologies to substantially increase the efficiency of the Nation's appliances will be conducted.

- Thermally Activated Heat Pumps (TAHP)

The primary objective of the work to be performed in this area of thermally activated heat pumps is to demonstrate new gas fired heat pumps for commercial and residential usage which will provide an exceptionally high coefficient of performance, especially in the north central United States. In FY 1976, a project was initiated in the area of commercial TAHP's. Under this endeavor, market research evaluated the overall development and commercialization sequence for the heat pump as a product; system studies translated the results of market research into technical objectives for optimization and design trade-offs in support of system design efforts; and system integration efforts designed, fabricated, tested, and determined production costs for the system and components.

In FY 1977, the systems integration work for the TAHP will be completed and data will be fed into the market research and systems studies efforts. In FY 1978, sales, services, and publicity planning efforts are projected to be completed by the TAHP potential manufacturer. The second of the Stirling/Rankine TAHP systems will be designed, fabricated, assembled, and tested.

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- Energy Management in Buildings

  The work being performed by Brookhaven National Laboratory in this area will provide the technical basis for reduced consumption of oil and gas, and promote the efficient use of energy in space conditioning of residential and small commercial buildings (i.e., control for optimum management of thermal energy flows in buildings).

  During FY 1976, the experimental objectives were defined, experimental methods were developed, and actual testing of oil burner furnace/boilers was begun. In FY 1977, thermal storage media, window devices and innovative design of high efficiency oil fired space heating systems and field efficiency measurement devices occured. In FY 1978, field testing and experimental data analysis of the systems and devices developed will be performed.

- Buildings System Controls

  Sensors will be developed for cheap and reliable remote sensing of humidity, temperature, incident radiant flux, occupancy, and other parameters that are found to be significant in determining the total and instantaneous energy demands of a building.

  In FY 1976, a conference on controls was held to identify technical alternatives and R&D on the most promising options was initiated. In FY 1977, optimization of approaches selected in FY 1976 occurred, and demonstrations of the most promising energy saving and cost effective candidates began.

  In FY 1978, demonstration of the most promising energy saving and cost effective candidates will continue.

- Efficient Light Sources/Ballasts

  In FY 1976 and FY 1977, R&D to optimize an electrodeless, magnetically excited, screw-in fluorescent lamp suitable for the large residential and commercial incandescent replacement market was conducted. In FY 1978, this screw-in fluorescent lamp project will be concluded, a demonstration will be conducted, and commercialization of this lamp will be explored. A program will be selected from those explored in FY 1977 and initiated to result in low lighting levels and advanced lighting controls in commercial buildings.

- Seasonal Performance Factor (SPF) Evaluation for Heat Pumps, Heating and Cooling Equipment

  This project to be initiated in FY 1978, will result in methods being developed that determine the true capacity and efficiency of space conditioning equipment on a seasonal basis.

- Infrared Thermography (IR)

  Infrared thermographic techniques have been developed, and are being applied on a very small scale commercially for the detection and description of heat loss from buildings. Both ground based and aerial approaches have been developed. In FY 1976 and FY 1977, IR technology uses, users, technology, and opportunities were defined resulting in an R&D agenda with attached priorities.

  In FY 1978, the most promising technical alternatives for the development of instrumentation and techniques of data gathering and analysis relevant to the needs of specific user groups, will be pursued in research and development.

- Space Conditioning

  In FY 1978, R&D will be initiated on high priority technical space conditioning options specifically including new and refit equipment for gas fired furnaces and oil burners. Results from this project will provide a rational means for selecting future RD&D space conditioning programs and commercialization of high priority options. Energy saving from modifying oil and gas fired burners can amount to 14-26 percent per modification.

- Residual Fuel Oil

  During FY 1978, an R&D program for the development of automatic combined monitoring/control equipment using residual fuel oil will be initiated. In an earlier study conducted during FY 1977, a major innovation was selected and efficiencies for fuel oil boilers were increased to 60 percent by upgrading boilers. In FY 1978, there will be investigations and demonstrations of conversions and other techniques to conserve fuel in commercial buildings.

- Thermal Distribution in Buildings

  This project will be initiated in FY 1978. The present means of distributing thermal energy in buildings is via air in ducts, water in pipes, or electricity. Other thermal distribution means are available that include, but are not limited to, heat pipes and related devices. Some of these systems can distribute thermal energy without consuming pump or fan motor energy.

- Insulating and Optical Materials

  There is ample opportunity for improvement of materials that are used in the fabrication and construction of major components of buildings to effect significant energy savings.

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During FY 1976, this project identified the most promising avenues for materials R&D, including insulation, lightweight construction, thermal storage of low-grade heat and other materials. In FY 1977, R&D on the most promising ones was initiated and plans were developed for demonstration activities. In FY 1978, demonstrations of the most promising technical opportunities of insulating and optical materials will be conducted in accordance with the plans developed in FY 1977.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
E. Consumer Motivation and Behavior.....	B/A	$395	$980	+ $585
	B/O	375	750	+ 375

The objective of the Consumer Motivation and Behavior category is to reduce the absolute level of energy usage in buildings and community systems by motivating individual consumers to accept and use new cost effective and energy efficient technologies, and to adopt and maintain energy conserving behaviors and practices.

Examples of activities to be undertaken in this category include:

- Strategies for Master Metered Buildings -- Concerned with development of motivational strategies for occupants of master metered buildings. In FY 1977, promising strageties were identified. A demonstration will be conducted in FY 1978 in cooperation with an office and/or apartment building.

- Low Income Housing: Behavioral Strategies to Assist Residents in Reducing Consumption -- In FY 1977, arrangements were made with a major public housing authority to test behavioral strategies to assist tenants in saving energy. In FY 1978, the most sucessful strategies will be "packaged" for transfer to other housing authorities, in cooperation with HUD and the National Association of Housing Managers.

- Marketing Strategies -- In FY 1977, strageties were developed to motivate relatively unsophisticated consumers and bulk buyers to purchase higher first cost energy efficient technology in cooperation with manufacturers. In FY 1978, plans will be developed for applying these strategies to specific program products, such as the Litek bulb and consideration will be given to ways of generalizing such strategies to development of a "conservation ethic" which would encompass many diverse energy efficient technologies and practice.

- Motivation and Feedback -- Application of behavioral science theory and findings to the task of assisting consumers to utilize energy more efficiently offers significant potential for energy savings which has not yet been adequately explored. In FY 1976, a contract was initiated with Princeton University physchologists to begin to identify promising strategies which might be utilized on a large scale. Emphasis in FY 1977 was on testing and refining those

approaches which appeared most promising, particularly provision of feedback. In FY 1978, a demonstration of a larger scale feedback project will be conducted and evaluated and results will be disseminated.

- Institutional Barriers and Opportunities -- In FY 1977, activities were initiated in cooperation with other program categories to identify institutional opportunities to encourage energy conserving behavior of individual consumers. In FY 1978, emphasis will be placed on delivery mechanisms for increasing the purchase of energy conserving technologies. The life cycle costing demonstration program involving retail merchants and financial institutions will be evaluated.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
F. Economic Analysis and Technology Transfer.....	B/A	$625	$2,200	+$1,575
	B/O	500	1,800	+ 1,300

The objective of the category is to assist in promoting the acceptance of new and existing means of improving the efficiency of energy use. There are a number of reasons for an in-depth involvement in the functions of systems analysis and technology transfer. These include the fact that competitive forces in many cases are insufficient to cause adoption of energy conserving technologies as soon as they are available and Federal support will accelerate the onset of these technologies; user and consumer needs differ by location, thus there may not be enough incentive for large marketing efforts by the private sector; and individual consumers lack sufficient market force to precipitate action. Various barriers which impede the adoption of energy conserving technologies include a lack of information on available techniques, lack of information to assess costs and benefits, aversion to risk, lack of capital, lack of motivation, limited technical resources to assist in assessing and adopting energy saving technologies and user preferences for lower first cost versus lower long-range operating costs. While identification of all factors and removal of all barriers is not possible, the use of analytical tools and technology transfer techniques will provide both the developer and the user of technology the necessary information upon which to base an intelligent decision.

The overall strategy of technology transfer is to disseminate information on energy saving measures to energy consumers through a variety of channels and products. For the Buildings and Community Systems programs the primary consumer is the professional who builds or manages buildings and community systems, the homeowner and the manufacturer who supplies that sector of the economy. The channels to be used include presently operational programs, such as the Cooperative Extension Service, state university outreach programs and other existing Federal agencies (e.g., FEA, HUD, NBS, Federal Laboratories, and NSF Urban Technology Agents) information transfer programs.

(Dollars in thousands, except whole dollars in narrative material)

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The functions in this category support and will help to assure that technology developed as part of the Buildings and Community Systems subprogram achieves the energy savings projected.

Examples of activities to be undertaken are:

- Publication and Exhibits

  Executive technical briefing reports, technical status reports, technical manuals, and exhibits provide executive decision makers, technology oriented managers and technicians information on energy conserving technologies and techniques. Each product is directed to a specific audience (e.g., the executive briefing reports which give the executive information essential to a grasp of the implication of a new technology), and contains the level of detail appropriate to the audience. In 1977, five major publications and several exhibits were sponsored. In FY 1978, it is planned to sponsor twelve major publications and four exhibits. Included in the schedule are the Annual Cycle Energy System, Comprehensive Community Energy Planning, and Building Insulation Technology.

- Demonstration Programs and Seminars/Workshops

  The channels used to convey energy conserving technology constitute another major aspect of this category. Demonstration programs are designed to both test new approaches to technology and information transfer and to support those programs proven worthwhile. User committees were tested in FY 1977 and will be continued in FY 1978. Innovative approaches to information dissemination are carried out under this program and support of such programs will continue in FY 1978.

- International Programs

  During FY 1977, a number of milestones were met. Four IEA energy conservation R&D working party meetings were organized and conducted, including approximately 20 expert group sessions. Those meetings produced five cooperative, international research and development agreements. Each agreement is designed to leverage ERDA research funds and provide useful technologies and data for U.S. application. In FY 1978, five additional agreements will be proposed. Also, the work being conducted under the five original agreements will be coordinated and technology transfer opportunities developing from the work will be exploited.

(Dollars in thousands, except whole dollars in narrative material)

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- Modeling

  Linear programming and econometric models provide information essential to the determination of areas of greatest energy savings and potential for changes in the commercial and residential sector. In FY 1977, the Reference Energy System and the Energy Optimization Model were modified to simulate household energy use on a national level for the period 1970-2000. During FY 1978, the Reference Energy System work will be revised to incorporate necessary changes (i.e., climatic, topographic) in order to show impact demands on a regional basis. In FY 1977, an econometric model of household energy consumption, a model for predicting the rate of market penetration of new technologies and a commercial sector inventory model to estimate energy use were all initiated. In FY 1978, each of these models will be revised and exercised accordingly.

- Developing Procedures for Project Evaluation and for Determining Secondary Impacts

  During FY 1977, a comprehensive evaluation system was established to compare the cost effectiveness of individual energy conservation programs. During FY 1978, this program will apply a project evaluation procedure to aid managers in evaluating proposed, in process, and completed research in terms of end use energy conservation goals.

  The secondary impact study will provide the information to identify and analyze non-technical problems arising during the course of individual conservation projects which may delay completion of demonstration or result in increased project costs. In FY 1978, an Input/Output model will be developed to determine the impact of RD&D energy conservation expenditure on employment.

(Dollars in thousands, except whole dollars in narrative material)

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		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
3. Transportation Energy Conservation	B/A	$27,170	$86,000	+ $58,830
	B/O	23,790	55,950	+ 32,160

Category	Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual Transition Quarter B/A	Actual Transition Quarter Obs.	Actual Transition Quarter B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
A. Heat Engine Highway Systems ...	$ 7,759	$ 7,973	$ 9,328	$1,868	$2,487	$3,610	$16,385	$16,678	$14,740	$30,000	$23,200
B. Alternative Fuels Utilization .	733	338	128	212	465	354	1,785	1,785	1,550	2,380	1,900
C. Electric/Hybrid Vehicle Systems	1,605	1,486	789	340	407	29	5,000	5,000	4,000	46,900	26,250
D. Non-Highway Transport Systems .	510	493	76	150	153	180	500	500	500	2,800	1,700
E. New Concepts/Impact Assessments	1,933	1,951	1,069	630	683	1,165	3,500	3,500	3,000	3,920	2,900
Total Transportation Energy Conservation	$12,540	$12,241	$11,390	$3,200	$4,195	$5,338	$27,170	$27,463	$23,790	$86,000	$55,950

Objectives: End use of petroleum-derived fuels in the transportation sector is higher than end use in all other energy-consuming sectors in the United States. Petroleum energy consumption, specifically in this sector, has continued its virtual unconstrained increase since the oil embargo was terminated in 1973. For example, motor gasoline consumption increased by 2.1% in CY 1975 and during the first three months of CY 1976 it grew 5.2% more than during the similar period in 1975. In fact, recent data available in CY 1975 indicate that total transportation sector energy consumption has increased by about 13% (2.0 Quads) since 1970, amounting to 26% of all energy consumed in the United States. The Transportation Energy Conservation (TEC) subprogram addresses this continuing problem, seeking practical technical, operational, and institutional changes to hasten solutions, thereby effecting actual energy consumption reductions.

The TEC subprogram has been formulated to support four national energy goals, as defined in ERDA 76-1, the primary goal being to increase end-use efficiency. Goal achievement is highly dependent on cooperative ventures with other Federal agencies, as described in detail elsewhere. Objectives defined for the TEC subprogram are those for which attainment is controllable by ERDA alone, with due consideration of realistic budgets. These objectives serve as the ERDA input in support of the national goals. Specifically, the TEC subprogram seeks to:

- Improve overall efficiency of energy use in transportation to produce a 25% reduction from levels now projected for the year 2000.
- Reduce and eventually eliminate transportation's present dependence on petroleum.

The mid-term (-1990) objective is to ensure that new, energy-efficient technologies and systems are made available to continue reductions in petroleum energy consumption in the transportation sector. Certain technologies for which development is to be initiated in the program in the 1970's, such as those relating to efficient auto engines, are expected to begin their appearance in the marketplace by the mid 1980's. This should be a significant factor in reducing petroleum dependency by 1990.

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The long term (2000) objective is to ensure that the needed energy-efficient technologies are in a state of readiness to permit elimination of the dependence of the transportation sector on petroleum energy while efficiently utilizing energy resources available in abundance in the United States.

Each of these objectives will be pursued with appropriate environmental constraints.

Estimated energy savings based on the technological potential for this subprogram are shown in the following table:

Potential Energy Savings Resulting from the Transportation Energy Conservation Subprogram (thousands of BPDE)

	Crude Petroleum*		Energy Savings**	
	1985	2000	1985	2000
Total Subprogram.....	500-700	4000-6000	300-400	2500-4000

* Crude petroleum is saved if a transportation vehicle substitutes an alternative fuel for crude petroleum products.
** "Energy Savings" is the crude petroleum minus the alternative energy used.

Federal Role: The transportation sector is complex, subject to many noneconomic forces and regulations, and not easily redirected without disturbing long-term technological and capital equipment commitments. Present industrial investment in plants, equipment and production tooling is enormous. In the allocation of funds by vehicle firms, relatively high risk development projects, such as very efficient but revolutionary engines, do not warrant high priority--especially when the American public is apparently willing to purchase the industry's products regardless of their fuel consumption.

ERDA, through cost sharing with industry, is acting as a catalyst to spur development of more efficient methods of transportation. The cost sharing approach reduces the size of the individual private and Federal financial commitments while maximizing their effectiveness. An industry-government partnership will stimulate basic research on new systems, accelerate work on promising systems, and hasten eventual commercialization by industry of these systems.

The Federal role with respect to highway vehicles is well defined. That role is to support technology development by industry of those high risk, high cost projects which, if successful, could significantly improve the current negative energy and environmental influences of highway vehicles in the United States. In recent months, the auto industry has made moves to vigorously support this role, including proposals for cost sharing research and development.

The nonhighway area, which includes pipelines, rail, marine, and aircraft, generally has had traditional Federal roles. In the case of aircraft, the research role of NACA and now NASA, as well as that of DOD, is well established. The role is to support basic and applied research and development leading to improved aircraft performance, lower emissions, and reduced noise.

Pipeline research and development relating to energy conservation is relatively new. No Federal agency was involved until ERDA began work. Since 1976, contract work has been underway in TEC to assess the targets of opportunities for pipeline energy savings, to determine the extent of industry research, and to recommend a Federal role and an ERDA role, as appropriate, This information will be available in FY 1977.

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For the marine and rail modes, the Federal Government has pursued a limited research and development role through DOT, DOC and DOD. ERDA will play a joint supporting and coordinative role by encouraging and conducting energy related research and development. Assessments of energy saving potential for rail and marine systems are also part of the TEC program to be completed in FY 1977.

The achievement of actual energy consumption reductions calls for work on the part of other Federal agencies as well as ERDA. Agreements already have been reached in this regard. For example, in the case of energy conservation in transportation, ERDA is developing energy-efficient technologies and promoting their commercialization by industry; FEA is promoting to the public the use of energy-efficient products produced by industry. Also, the DOT is promoting use of known, and mainly unused, energy-efficient technologies by the trucking industry. Accordingly, this ERDA program for FY 1978 was formulated with full knowledge of other agency programs and responsibilities. The program is coordinated to ensure that duplication is avoided, that the ERDA program supplements or complements other agency programs, or that the lead role of ERDA is supported by other agencies.

Accomplishments: Significant recent (FY 1976/TQ) accomplishments and major milestones targeted for FY 1977 include:

- A successful durability test for an existing gas turbine engine under stringent test conditions. The engine accumulated over 150,000 equivalent road miles.
- Initial testing on the new gas turbine engine, indicating improved fuel economy and low noise level.
- Completion of the design for a new 80-100 hp Stirling engine.
- Testing of a new ceramic regenerator for over 6400 hours without visible deterioration. This is a critical component in the development of high efficiency gas turbine and Stirling engines.
- Installation of a continuously-variable transmission in an automobile, which demonstrated a fuel economy improvement of 25% over conventional transmissions in highway driving.
- Completion of preliminary designs of advanced technology electric vehicles by three contractors.
- Initiation of baseline evaluation of the currently available electric vehicle and completion of evaluation of four vehicles.
- Completion and distribution of the first edition of the Transportation Energy Conservation Data Book, a collection of historical and current data for transportation demand and energy use for the establishment of energy relationships.

Budget Request: The TEC program comprises four main thrusts. The types of activities in each thrust are quite different and each requires a somewhat different approach. The key element in the strategy for each thrust is to involve the affected industry in both the planning and execution of TEC projects. Experience in recent years has shown that the transfer of technology from government research programs has been slow when it depends on the usual information dissemination techniques to inform industry of technical advances made by others outside of that industry. Since industry will ultimately produce the products which use new technologies derived from the program, the program should involve, from the beginning, those industries most

knowledgeable on the subject area. Of course, those outside of an industry area may also contribute to the program. An important ERDA role is to orchestrate and integrate the results of high technology firms under ERDA contract with the results of ERDA contract work with the transportation industry.

The four main thrusts of the program are:

Heat Engine Highway Vehicle Systems - Autos, trucks, and buses consume 75% of the total transportation energy. Industry is applying known technologies to effect gradual, annual fuel economy improvements. The most significant potential for improvement in fuel economy resides in new propulsion systems (engine and transmission). Development of new systems involves considerable cost and risk and is not being pursued with vigor by industry. ERDA will accelerate these developments by working in partnership with industry. Contributions by industry will become increasingly larger over a seven-year period. At the end of that time, decisions on limited production can be made by industry. For FY 1978, an increase of $12,464,000 is required for the development of hardware for gas turbine and Stirling cycle technologies.

Electric and Hybrid Vehicle Systems - These vehicles offer promise of playing a significant role in the personal and light commercial transportation system by 1990 because petroleum fuel usage can be significantly reduced or completely eliminated. They may also offer economic advantages to the user, particularly in the light commercial area. The major research and development activity in cooperation with other divisions is the identification and design of significantly improved components (improved lead-acid and nickel-zinc batteries, flywheels, motors, controls, etc.) followed by system design and testing in a complete vehicle. Advanced systems will incorporate more advanced (high temperature) batteries and other components to extend the range and improve the economics of electric/hybrid vehicles. The FY 1977 budget figures contained herein do not fully reflect funding needed to implement P.L. 94-413. ERDA is presently evaluating technical and financial requirements for FY 1977. The FY 1978 budget provides for accomplishment of the required R&D activities, demonstration and financial incentive program required by P.L. 94-413.

Alternative Fuels Utilization - The approach in this thrust is to work with industry and universities to understand and solve the practical problems associated with use of new fuels derived from nonpetroleum resources. The order of priority of effort is based on the nearness of these fuels to the marketplace. This results in the following order: methanol/gasoline blends, methanol, hydrocarbon fuels from shale and coal, and hydrogen.

Nonhighway Transport Systems - The nonhighway segment of the transportation sector utilizes 25% of transportation energy now. This is projected to grow to 40% by 2000. By FY 1978, the energy-saving potential in the aircraft, pipeline, rail, and marine areas will have been established and certain specific projects identified for initiation to demonstrate savings. Balance to all nonhighway modes is emphasized, together with close coordination with other involved Government agencies. The thrust in FY 1978: will provide further support for the identification of more energy-conserving projects; will initiate the hardware demonstration of a pipeline pumping station waste heat recovery system; and will jointly support energy conservation projects on rail and ship systems with DOT (FRA) and DOC (MARAD), respectively.

Another segment of the TEC subprogram supporting the main thrusts described above is New Concepts/Impact Assessments. This support function provides information and data on transportation energy, economics, environment, health, safety, societal data, and assessments of the potential impacts associated with the introduction of change to the transportation system and with use of new technologies.

(Dollars in thousands, except whole dollars in narrative material)

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		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
A. Heat Engine Highway Systems.....	B/A	$ 16,385	$ 30,000	+ $13,615
	B/O	14,740	23,200	+ 8,460

This category is oriented toward developing new energy-saving technologies for autos, trucks and buses which use combustion processes in the vehicle as the primary source of energy. The work is divided into two subcategories: (1) Heat Engine Systems and (2) Vehicular Systems. Heat Engine Systems activities focus mainly on development engines such as the gas turbine and those employing the Stirling cycle. Vehicular Systems activities comprise development of components of vehicles other than the engine; e.g., transmission. The work in this category emphasizes projects which complement the work of industry and which offer the potential for appreciable energy savings.

Heat Engine Systems - Hardware development of the most promising alternative engine systems to the conventional internal combustion engine is one important aspect of work in this subcategory. Specifically, the two engine systems receiving primary emphasis in development are the gas turbine and the Stirling cycle system, which are targeted for introduction into the marketplace in the mid- to late-1980's.

The current gas turbine development work builds both on the engine development initially funded by the auto industry in the 1950's and 1960's and on the work of other Government agencies since the early 1970's. Past development activities placed emphasis on metallic turbines which were inherently limited in their utilization of energy normally available from the high temperature combustion process in the turbine. The ERDA turbine engine development program has now progressed to the point where the new test engine has been fully characterized. A 40% deficiency in power has been measured. A corrective action program has been formulated that will allow the recovery of this power deficiency. Idle fuel consumption has been reduced substantially. The original 50% fuel economy improvement goal is still obtainable. This new engine uses a metal turbine wheel at a temperature which provides reliable operation and relatively high fuel efficiency of the engine. Interpretations of the tests of the individual components of the new engine indicate the fuel usage should be about 6% better fuel economy than that of the conventional 6-cylinder engine and 20% better than that of the conventional 8-cylinder engine. In addition, current estimates are that the new turbine performance matches that of the 8-cylinder. It appears that this new engine has the potential to meet the most stringent Clean Air Act standards and to burn virtually any combustible substance as fuel.

Starting late in FY 1976 and running parallel with testing of the new turbine, program work was initiated for advancing high temperature ceramics technology. The aim of this work was to permit the critical components of the turbine to operate at higher temperatures, up to 2500° F. This development work has progressed from component laboratory test to engine laboratory test on a component basis, substituting ceramics for metallic parts in the hot sections of the turbine. This work will continue in FY 1977 with more ceramic components (those more difficult to fabricate) integrated into the test engines. The test engines, which form the baseline on which fuel economy improvements with ceramics are being measured, are the new turbine engines developed at the near maximum temperature potential.

The features offered by the Stirling cycle system are similar to those of the gas turbine; namely, very high efficiency, virtual pollution-free emissions and multifuel capability. The Stirling cycle system development effort began in FY 1976 with a preliminary design study of an engine for compact-car-sized vehicles. In late FY 1977, the hardware development contracts are to be awarded and technologies work funded. In this development effort, the baseline engine on which performance improvements are measured is a 170 hp engine developed earlier by Ford Motor Company and Philips, The Netherlands.

FY 1978 plans call for proceeding with increased testing of the baseline engine, technology advances in seals and ceramics, and a redesign or updating of a new engine based on results of the baseline tests and technology advances.

Recent accomplishments that have been made in the Heat Engine Systems Subcategory include:

- Initiation of development work on the Advanced Gas Turbine project. Ceramics materials and components developments were initiated.
- Initiation of testing of the new auto Gas Turbine Engine (100 hp).
- Demonstration of durability and performance of a ceramic heat exchanger in testing for more than 6400 hours of thermal cycling. This is a key element in a low cost, high efficiency gas turbine for autos and trucks.
- Successful completion of more than 4000 hours durability testing of a gas turbine engine (all metallic) under stringent test conditions. This corresponds to about 120,000 miles of normal consumer use.
- Continued dynamometer testing of a new form of internal combustion engine with pistons of variable displacement. Fuel economy improvements compared to the conventional engine of 25% were measured.

The shift from engineering and analysis to hardware development in both gas turbine and Stirling engine programs reflect the bulk of the budget increase. Planned accomplishments in FY 1978 are as follows:

Turbine:

- Complete conceptual and final design of improved technology gas turbine automobile engine.
- Procure hardware for improved technology engine.
- Initiate procurement of gas-turbine-powered bus in cooperation with DOT for limited city fleets.
- Advance durability limits of gas turbine ceramic components.
- Introduce a number of ceramic components into modified gas turbine engines.

Stirling:

- Complete engine map on first generation 170 hp design.
- Complete vehicle emission/fuel economy/dynamic performance tests on first-generation 170 hp design.
- Continue conceptual and final design of second-generation 170 hp engine.
- Improve heater head component technology.

Vehicular Systems - This subcategory has two characteristics: (1) component improvements offer the potential for production and introduction to the marketplace early in relation to production of a completely different engine, and (2) successful development efforts will be applicable to any auto engine produced, whether it be the internal combustion engine, Diesel, gas turbine or Stirling. Highlights of accomplishments over the past year in the area of vehicular systems development include:

- A new engine accessory drive unit developed in the program was tested in a vehicle for 2500 miles of highway driving with a resultant 8% improvement in fuel economy. (Phoenix-Detroit)
- A first-generation Hydromechanical Transmission installed in an automobile demonstrated a fuel economy improvement of 25% shown in highway driving. (San Diego-Detroit)
- Designs and packaging for the waste heat utilization system (bottoming cycle) were completed in conjunction with a Diesel truck engine. Initial testing of available components to demonstrate feasibility was completed earlier and showed the equivalent of a 13% increase in a fuel economy of the complete engine system.
- A regenerative braking accessory system was fabricated.

In FY 1978, the efforts in accessory drives, transmissions, and engine technology will include the following specific objectives:

- Testing of a second-generation hydromechanical, continuously-variable transmission in a vehicle.
- Initiation of a single vehicle test of regenerative braking accessory drive.
- Completion of specifications of an energy-optimized vehicle system.
- Evaluation of fabricator techniques.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
B. Alternative Fuels Utilization.....	B/A	$ 1,785	$ 2,380	+ $ 595
	B/O	1,550	1,900	+ 350

In order to reduce the dependence of the transportation sector on domestic and foreign petroleum sources, it is essential that the technology for utilizing nonpetroleum-based fuels be developed for use in both conventional and alternative automotive engines. The work in this area is aimed at (1) identifying and resolving all potential problem areas related to

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the utilization of alternative fuels and (2) providing a broad-based understanding of the practical problems and systems aspects associated with the implementation of alternative fuels in conventional automotive engines. Past overview studies on this subject have indicated that the most promising alternative fuels for highway vehicles are:

Category	Applicable Time Frame
Alcohols (methanol) and alcohol/gasoline blends	Near-term
Synthetic gasolines and distillates	Middle-term
Hydrogen	Long-term

These alternative fuels must be compatible with automotive engines in use and must obey the constraints imposed by economic and environmental criteria. The following are some of the major problems associated with the utilization of these fuels:

Fuel	Problems
1) Alcohol	Cold start, fuel metering, optimum system, safety
2) Alcohol/gasoline	Phase separation, vapor lock, driveability, safety
3) Synthetic gasoline and distillates	Characterization of fuels, safety
4) Hydrogen	On-board storage, optimized engine, safety

The primary problem associated with 1), 3), and 4) appear to be economic in nature and focus on the expected relatively high cost to the consumer. Work is also needed on material and lubricant compatibility, as well as emission characterization for the above fuels.

Recent accomplishments made in this category include:

- Continued experimental research to characterize alternative fuels combustion in conventional Otto cycle engines. Research was conducted at University of Miami (methanol), University of Santa Clara (methanol), and ERDA, Bartlesville, Oklahoma (methanol and synthetic hydrocarbons from coal and oil shale).
- Analysis of the most promising modifications to conventional Otto cycle engines to support methanol combustion.
- Analysis of the most promising modifications to methanol fuel to support combustion in conventional Otto cycle engines.
- Analysis of the possible and most promising trade-offs between modification of methanol fuel and/or engines for optimum combustion in conventional Otto cycle engines.

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Specific objectives for FY 1978 include:

- Initiation of research and testing of methanol and synthetic hydrocarbon fuels to characterize emissions, fuel composition and properties, and to understand materials and lubricant compatibility problems, as well as toxicity and safety problems.
- Completion of studies on the effectiveness of selected methods to reduce cost of alcohol fuels to the consumer.
- Expansion of research characterization of hydrogen fuel combustion.
- Expansion of testing of synthetic fuels from shale and coal in autos and trucks.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
C. Electric/Hybrid Vehicle Systems.....	B/A	$ 5,000	$ 46,900	+ $41,900
	B/O	4,000	26,250	22,250

The electric and hybrid vehicle systems category focuses on options to reduce or completely eliminate petroleum as the energy source for the conventional automobile and light truck. The electric vehicle uses electricity stored on board the vehicle in electrochemical form in a battery as an energy source. The battery can be recharged from standard home electrical systems. The hybrid vehicle employs a combination of two or more energy conversion and/or storage devices, such as heat engines, fuel cells, batteries, flywheels, etc. The basic hybrid concept features means to extend the range of battery-powered electric vehicles.

The electric vehicle activity focuses on improving existing and developing new propulsion systems for automobiles, vans, and buses which employ an electric motor with batteries, fuel cells, flywheel generator, or other means of providing electric current as the power source. An integral part of these activities includes studies of complete vehicular systems using power sources external to the vehicle for range extension, such as inductive coupling of electrified roadways.

The primary reason for conducting development on these types of automotive systems is that most of them are rechargeable from readily-available electric energy sources in homes or industry. Presently, about 17% of the Nation's electricity is generated by petroleum energy; therefore, if new and efficient systems can be developed, their use could allow an immediate reduction of petroleum consumption. In addition, their use facilitates the ability to switch to alternative energy sources such as coal, nuclear, solar and geothermal energy. Fuel cell systems can be chemically recharged with non-petroleum-based fuels. Other potential advantages include quiet operation, very little adverse environmental impact, low maintenance, durability, and compatibility with a load leveling function favored by electric utilities. Lastly, the potential national benefits of petroleum savings and contributions to solution of the energy problem are additional motivating factors for developing efficient electric vehicle systems.

Public Law 94-413 was enacted on September 17, 1976. The Act authorizes the Energy Research and Development Administration a Federal Program of research, development and demonstration designed to promote electric and hybrid vehicle technologies and to demonstrate the commercial feasibility of electric and hybrid vehicles. The requirements of the Act are in addition

to an established base program in electric and hybrid vehicles within ERDA, planned to advance the technology of components and vehicular systems.

The FY 1977 effort, in support of P.L. 94-413, accomplished most of the mandated studies, characterized the state-of-the-art, and established performance standards. The principal activity of the base program was to initiate fabrication of an advanced technology electric car, and continue electric drive system assessments. The amended FY 1978 budget contains a request for $40,000,000 to implement the Electric and Hybrid Vehicle Act. This request includes a suitable amount ($14,000,000) to initiate procurement of vehicles for the demonstration required under the Act. Provisions for loan guarantees, also required under the Act, are also included in FY 1978 in the amount of $2,000,000. A comprehensive study of both the risks and opportunities of electric vehicle demonstration is being initiated with a target completion date of September 1, 1977. As the results of this analysis become available, we will be in a posture to either implement the demonstrations as called for in the legislation or to work with the Congress to constructively modify the specifics of the demos, depending upon the results of the study. FY 1978 funding in the amounts shown below are required for the orderly continuation of the electric and hybrid vehicle program and that required by P.L. 94-413.

	B/A	B/O
Demonstrations	$14,000	$ 5,000
Financial Incentives	2,000	250
Specifications, Studies, & Reports	2,500	2,000
Technology Development	18,200	10,000
Energy Storage	9,000	8,000
Engineering Support & Assessments	1,200	1,000
TOTAL	$46,900	$26,250

Demonstration and Financial Incentives - There is $14,000,000 devoted to the purchase of vehicles and implementation of demonstration activities in accordance with the schedule outlined in P.L. 94-413. The loan guarantee program required by the law is allocated $2,000,000.

Specifications, Studies, and Reports - Assessments of material demands and pollution effects, and incentives to promote broader utilization and consumer acceptance of electric and hybrid vehicle technologies are required to be continuously conducted. State-of-the-art assessments must continue and performance standards must be re-examined. These efforts will require $2,500,000 funding in FY 1978.

Technology Development - The primary purpose of this effort is to advance the technology of electric and hybrid vehicle systems and sub-systems (including batteries) so that future vehicles can be sufficiently high performance to be of commercial interest. Whereas current electric vehicles typically have 20-40 mile ranges on urban driving cycles between 8-hour recharges, the advanced vehicles which could result from this technology effort could have at least 75-mile range with advanced lead-acid batteries, and 110 miles within nickel-zinc or nickel-iron batteries. When high temperature

sodium-sulfur or lithium-sulfur batteries become available, ranges up to 200 miles might be expected. It is planned that vehicle systems research and development be supported in FY 1978 with $10,000,000 drivetrain sub-systems be supported with $8,200,000 and that $9,000,000 be devoted to battery programs, the majority of which is devoted to advanced lead-acid, nickel-zinc and nickel-iron batteries and to augment the ongoing advanced battery program for sodium-sulfur, lithium-sulfur, and zinc-chloride batteries.

Engineering Support and Assessments - This effort for FY 1978 is $1,200,000, continuing efforts begun in FY 1977, and provides for advisory committee and engineering support plus continuing effort on opportunity/risk analyses of the overall program.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
D. Nonhighway Transport Systems.....	B/A	$ 500	$ 2,800	+ $ 2,300
	B/O	500	1,700	+ 1,200

Work in this category addresses itself to reducing energy consumption and petroleum dependency in the nonhighway transport modes of rail, marine, air, and pipeline with the overall objective of providing technology needed to attain a 25% reduction in energy usage over the no new initiatives case by the year 2000. The nonhighway modes are currently identified as consuming approximately 25% of all transportation-related energy with projections of growth to 40% of transportation by the year 2000. The approaches toward achieving energy conservation in nonhighway systems can, in general, be placed into two groups: (1) those efforts aimed at reducing energy consumption by attaining improved efficiency of fuel conversion or increased productivity per unit of energy consumed and (2) those efforts designed to provide alternate fuel/energy sources which, while not necessarily reducing energy consumption, will decrease dependency on petroleum-derived fuels. Specific approaches will vary depending on the constraints of the particular transport mode and the related activity of other involved Federal agencies. Coordination of program plans with other agencies into a comprehensive national energy conservation effort and joint agency support, where appropriate, will be emphasized.

During FY 1977, baseline studies in the rail, marine, and pipeline modes are to be completed. These studies provide a comprehensive examination of the energy-use patterns and characterization of each system, including technological, operational, and institutional factors. Information thus obtained will be utilized to identify, define, and prioritize research, development, and demonstration programs related to nonhighway energy conservation for support in subsequent years. A Coal Transportation Study, intended to establish specific coal transportation needs and to provide recommendations for future research, development, and demonstration programs for improving coal or energy transportation efficiency involving all transport modes, is to be completed in FY 1977.

The following three projects will be initiated in FY 1977:

- Preliminary design and economic analysis of a pipeline pumping station with a heat recovery system for improved energy efficiency (20%).

- An Alternative fuels/energy analysis to develop a broad understanding of potentially available alternate fuels/energy sources and their availability and suitability as primary fuels for nonhighway transport.
- A study of the economics, energy consumption, equipment availability, and capital requirements for transporting energy materials in the 1980's and beyond.

The FY 1978 program will consist of the following projects:

- Continuation of the alternate fuels/energy study initiated in FY 1977 and identification of appropriate research, development, and demonstration activity in each transport mode for future support.
- Continuation of the transport of energy materials study.
- Assessment of the viability of utilizing various nonpetroleum-derived fuels or relaxed-specification fuels as contingency fuels in the event of a severe curtailment in the availability of petroleum.
- Analysis of futuristic concepts and technologies applicable to nonhighway systems.
- Research and development leading to the demonstration of a pipeline pumping station with a heat recovery system, based on criteria established in the preliminary design and assessment initiated in FY 1977.
- Assessment of the national needs and availability of laboratory facilities to support energy research and development activity on pipeline advanced systems.
- Development of joint energy research and development programs with the Federal Railroad Administration and the Urban Mass Transportation Administration, based on results of baseline rail energy study completed in FY 1977, including joint support of a rail electrification study.
- Development of joint energy research and development programs with MARAD based on results of baseline ship energy study completed in FY 1977. The program will consist of ship performance - waste heat recovery, advanced propulsion machinery, hull drag reduction, etc.; ship operation - weather routing, cargo pooling, ship scheduling; and domestic shipping - scheduling, speeds, loads, routing, etc.
- Planning of operating strategies demonstrations for commercial airlines with energy saving potential. To be based on results of survey conducted in FY 1976.

Program Accomplishments to Date

- Completion of economic assessment of application of a waste heat recovery system to typical gas and oil pipeline pumping stations, indicating systems appear economically attractive.
- Completion of survey of commercial airline operating strategies, holding promise for achieving energy savings.
- Completion of study of use of liquid hydrogen as a primary fuel for the rail transport system.

E. New Concepts/Impact Assessments		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
	B/A	$ 3,500	$ 3,920	+ $ 420
	B/O	3,000	2,900	- 100

This category provides for the gathering and analysis of technical information to support the Division in a number of areas that include: (1) an adequate and consistent energy usage and supply and demand data base; (2) objective evaluations of new concepts for transportation energy conservation offered by the public; and (3) an understanding of the economic, social, and institutional barriers facing commercialization of new technologies.

New Concepts/Impact Assessments was initiated in FY 1976. The program effort to date has resulted in the development of baseline information, such as the characteristics of the various transportation systems, development of benefit-cost analyses, development of analytical models for forecasting energy consumption and development of methods for trade-off selections of research, development, and demonstration projects.

This category is divided into three subcategories: technology assessment and implementation, data analysis, and new concepts.

Technology Assessment and Implementation

This subcategory has two functions that are mutually supportive in establishing conditions under which specific advanced technologies may become successfully deployed in the future.

The Technology Assessment function examines the future relationship of technologies to the environment in which they are to be operated, given the need for the development of such technologies in solving the problems of the public. In an integrated approach, the multi-impact dimensions of energy (economic, environmental and social) are analyzed in a common framework that allows anticipation, identification, and quantification of those critical, limiting, or constraining secondary or tertiary effects arising from that particular technology. This analysis provides a consistent reference frame for comparing future alternatives and their performance in a large scale system application. This leads to evaluation of specific policies that determine which research and development investments ought to be pursued and the resulting soft science research and development necessary to support those technological developments. Published studies include those on

electric cars and alternative fuels for transportation, energy, transport, and electrification.

The second function, Technology Implementation, provides future data and information focused on technological information transfer. It is in direct support of the future commercialization of the technology which was a new start in FY 1977.

FY 1978 funding will be used to undertake a set of projects that will measure the impacts of alternative transportation energy conservation scenarios. The emphasis will cover the secondary and tertiary effects arising from any particular technology. This analysis will provide a consistent reference frame for comparing future alternatives and their performance in a large scale system application.

An Environment Development Plan for the Electric and Hybrid Vehicle program is being developed in FY 1977. Funding will be required to conduct Environmental Impact Assessments and formal Environmental Impact Statements for the two demonstrations of the electric and hybrid vehicle program.

Data Analysis

The objectives of this subcategory are: to collect, evaluate, and analyze historical and current data for transportation demand and energy use for the establishment of energy relationships; to establish a baseline transportation energy forecast that utilizes state-of-the-art forecasting methodologies; and to develop a scenario-generating capability and impact tool that will provide energy, economic, and environmental information associated with alternative transportation energy technologies.

Many Federal agencies are collecting data and making forecasts of future transportation demands. ERDA must pull these data and forecasts together and synthesize them in a form that assists policy making.

The first edition of the Transportation Energy Conservation Data Book (October 1976) collects much of the historical and current data. Quarterly supplements to this data book are providing an initial evaluation of some of the data and presenting the first baseline forecast. Forecasting models developed by FEA and DOT have been acquired and are being used to make forecasts. A methodology for generating scenarios is being established, and a comprehensive transportation energy accounting model is under construction.

In FY 1978, effort in this subcategory will be devoted to: filling data gaps that have occurred in the process of producing the TEC Data Book; analyzing surveys that deal with the mode of transportation used for personal travel; and analyzing the type of automobile/personal truck purchased and used by individuals, businesses, and fleet owners.

Specific gaps identified in the data include such things as average annual miles driven per personal vehicles, automobile vehicle-miles of travel by type of vehicle, use of trucks for personal travel, and vehicle purchases by fleet operators.

New Concepts Evaluation

This subcategory is established to seek out, evaluate, test, diagnose, and report energy-conserving technology concepts. Emphasis will be placed upon the evaluation of new concepts to save transportation energy proposed by individuals, universities, and small firms in all areas; e.g., highway systems or nonhighway systems. A number of promising energy-conserving projects will be selected for either research, development, or demonstration programs.

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The Federal role to support energy-related inventions or ideas is coordinated by ERDA. The Office of Energy Related Inventions in the National Bureau of Standards (NBS) conducts evaluations of promising energy-related inventions and makes recommendations to ERDA for potential funding, if warranted. ERDA considers these NBS recommendations as well as other unsolicited proposals in the selection of a number of these concepts for Government support.

More than 100 concepts have been evaluated to date. An example of a concept selection for support is the evaluating of a promising innovative technology for a retrofit, stratified-charge engine by laboratory and road testing. Another concept under field test, using the dedicated vehicles of an ERDA laboratory, is the fuel-saving potential of driver aids or training.

(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
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			Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
4.	Improved Conversion Efficiency	B/A	$23,150	$55,200	+ $32,050
		B/O	12,450	45,200	+ 32,750

Category		Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual Transition Quarter B/A	Actual Transition Quarter Obs.	Actual Transition Quarter B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
A.	Fuel Cells	$3,674	$3,674	$421	$576	$640	$3,141	$19,000	$19,000	$9,450	$28,200	$26,900
B.	Heat Cycles	1,682	1,619	648	701	776	1,175	1,850	1,850	1,250	11,800	7,290
C.	Combustion	910	981	769	238	212	241	850	850	580	7,200	5,960
D.	Sup Tech End Use Appl	834	690	149	185	205	483	1,450	1,461	1,170	8,000	5,050
	Total Improved Conv. Eff.	$7,100	$6,964	$1,987	$1,700	$1,833	$5,040	$23,150	$23,161	$12,450	$55,200	$45,200

Objectives

The Improved Conversion Efficiency subprogram was established to develop the technology base necessary to permit implementation of advanced conversion devices applicable to all fuel sources and to the end use sectors of buildings, community systems, industry, transportation, and electric utilities. To achieve this overall objective, generic supporting technology is generated and specific technology applications are pursued, directed at specific conversions; e.g., chemical to electrical, chemical to thermal, thermal to mechanical. The concept of a transition from oil and gas to alternate fuels in conversion devices is a major factor in all subprogram areas.

Almost all fossil fuels are expended in conversion devices in order that their chemical energy can be converted into useful forms of energy such as mechanical, thermal or electrical. The present efficiencies of conversion devices are well below the theoretical maximums. This is a result of the fact that energy costs have historically been low enough that it has not been cost effective for anyone to develop the necessary technology to improve these devices. For example, power plants convert chemical energy into electricity at efficiencies of 34% or lower. It is an objective of the Improved Conversion Efficiency subprogram to develop the technology necessary to increase this to 45-50% by 1990. Such an improvement would reduce fuel requirements by up to 1/3 in this use sector when fully implemented.

To accomplish these objectives, four major thrusts have been established to address the supporting technologies and the major conversion applications:

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- Fuel Cells - Fuel cells offer high efficiency direct conversion from chemical to electrical energy. First generation fuel cells can have a near term impact replacing existing 22% efficiency hardware with 38% equipment, and saving an estimated 275,000 barrels of oil per day by 1985. Second generation fuel cells are projected to be the most cost effective means of producing electricity in the 1987 to 2000 time frame.

- Heat Cycles - The heat cycles category consists of two effort areas; heat engines and components and heat utilization. These efforts are directed at development of devices which convert thermal energy into mechanical energy. Heat utilization addresses conversion of existing reject heat streams such as power plant waste heat and reject heat from industrial processes. 20% of this Nation's energy is currently being lost to the atmosphere in the form of industrial waste heat. The Heat Engines and Components effort addresses those systems which generate their own heat in combustors and then convert it to mechanical energy. Internal combustion engines and turbines are examples of machinery which currently operate at about 22% efficiency and which could be significantly improved.

- Combustion - The Combustion category addresses the conversion of chemical energy to thermal energy. Major efforts in this area will improve the efficiency of this conversion process and will allow development of combustion equipment which is suitable for the variety of new synthetic fuels now under development. Over 90% of fossil fuels are consumed in combustion processes.

- Supporting Technologies For End Use Applications - A major effort is directed toward establishing the technology base required to implement the conversion technologies discussed above. Specific areas of technology development include thermodynamics and heat transfer, materials and fabrication, controls and process efficiency and planning and analysis.

Federal Role

The government can play a significant role in the advancement of Improved Conversion Efficiency. A major effort is the traditional role of advancing the state of the art in the thermal sciences. Additionally, development and use of improved efficiency conversion devices can be accelerated by government funding. Studies of industry involvement in improving conversion efficiency have pin-pointed economics as the major reason why industry does not pursue conversion efficiency improvements. Fuel cost is generally treated as a raw ingredient cost which is passed directly on to the consumer. The electric utility fuel cost adjustment to customer bills is an example. Furthermore, fuel costs are only 10% or less of costs in the case of most products and, hence, a conversion efficiency increase of 10%, which would have a substantial Nationwide effect on energy use, would reduce the product cost (or increase profit) by only 1%. Therefore, the return on the R&D investment in conversion efficiency technology development is too low for industry to support such efforts.

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The projects of the Improved Conversion Efficiency subprogram are targeted to satisy technology needs of the end-use subprograms within the Conservation Research and Development Program. Close integration between this subprogram and the end-use subprograms is maintained during the initial program planning phases of the subprogram as well as during the implementation of those projects which are significantly directed at new technology development. As the constituent projects come to fruition, i.e., new technology is laboratory proven, the effort is transitioned either directly to industry or into a Conservation end-use subprogram, usually during a period of joint funding. The end-use subprogram then establishes a demonstration project to prove the technology in an operational environment. Such demonstrations are usually conducted by a representative industrial user teamed with the equipment manufacturer and the related trade association.

Accomplishments

In FY 1976 a major effort was initiated to demonstrate the applicability of fuel cells in electric utility systems. In addition to this major thrust a broad-based generic technology program is underway and providing the technology base necessary for conversion efficiency improvements throughout the marketplace.

Examples of Improved Conversion Efficiency projects which are providing input to industry or other Conservation subprograms are:

- Industrial burner combustion, heat exchangers, heat pipes, fuel cells, process efficiency technology and new heat cycles for industrial waste heat utilization for the Industrial Energy Conservation subprogram.
- Furnace combustion, heat pumps and heat pump fluids, and fuel cells and engine technology for total energy systems for the Buildings and Community Systems subprogram.
- Combustion and fuels technology for internal combustion engines, lightweight materials, high temperature materials, thermodynamic working fluids, heat pipes, friction and engine technologies in support of the Transportation Energy Conservation subprogram.
- Heat transfer, fuel cell, waste heat utilization and controls and diagnostics technologies for the Electric Energy Systems subprogram.
- Materials, heat transfer and thermodynamics technologies in support of the Energy Storage Systems subprogram.

Budget Request

In FY 1976 and the transition quarter, a broad-based subprogram was initiated in all the appropriate areas of conversion technology and supporting technology in the thermal sciences. Most of the efforts initiated were of a study or preliminary design effort. In FY 1977, a few of these areas, notably the fuel cell effort, will move into the more costly hardware development and experimentation phases. Major subprogram increases are required in FY 1978 to allow the continuation of the Fuel Cell effort and to permit advancement into prototype development of several projects in the Heat Cycle category. Expansions in the supporting technology areas are required to support expanded experimentation on those concepts identified in analysis efforts now underway.

Specific projects which will be increased, results to date, and objectives and justifications for each funding category are delineated as follows:

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
A. Fuel Cells	B/A	$19,000	$28,200	+ $ 9,200
	B/O	9,450	26,900	+ 17,450

The Fuel Cell category is the largest effort within the Improved Conversion Efficiency subprogram. Fuel Cells represent an energy conversion device which is flexible, modular, economically attractive, efficient and environmentally acceptable. For these reasons the fuel cell offers an energy choice of interest to a broad sector of the American economy. Fuel Cells represent the only technology which directly converts fuel and air to electricity without the constraints of a Carnot or thermodynamically limiting efficiency. They have the potential of generating electricity with hydrogen based fuels ranging from coal to solid waste. Extensive analyses have been conducted to define the benefits of fuel cell implementation and to determine the proper role for Federal involvement.

The first major impact of fuel cell technology is expected in the early 1980's when first generation phosphoric acid systems are incorporated into utility systems. These first generation systems are expected to replace the antiquated oil burning steam plants which presently exist in many high environmental impact locations. They have the potential of making significant penetrations into the peaking, intermediate load, and spinning reserve markets which are presently dominated by gas turbines. Installed simple cycle gas turbines are converting fuel to electricity at an average of 22% efficiency, thereby wasting 78% of the energy content. Presently operating fuel cell prototypes convert fuel to electricity at between 38-40% efficiency over 75% of their rated power range.

Fuel cells also offer significant energy savings (National benefits by 1985, from first generation technology, include 275,000 barrels of oil saved per day and $1,000,000,000 saved annually through use of this technology) by being utilized in such applications as the prime mover in integrated energy systems, and waste fuels recovery (e.g. industrial hydrogen, methane from coal seams, urban waste). Environmentally, fuel cell systems are completely acceptable and can be sited in residential or high population areas resulting in significantly reduced electric transmission losses. They would encounter no environmental impact problem when installed to replace present oil burning equipment in urban locations since they are quiet and emit virtually no pollutant gases.

In order to achieve the maximum potential National benefits from fuel cell technology, the overall fuel cell effort has been designed to:

(a) Commercialize first generation fuel cell systems as soon as possible in order to gain the associated national benefits of 275,000 barrels of oil per day saved and over $1,000,000,000 per year saved through lower electric costs by 1985.

(b) Generate a strong technology base for first, second, and third generation fuel cells in order to assure the lowest cost and highest reliability and efficiency of future systems. The emphasis in the technology base is on second generation (molten carbonate) systems which have the potential of being the most economic, coal using, base load, electric generation equipment from the mid 1980's through the year 2000.

(c) Generate the capability for the reliable, economic use of a broad range of fuels in fuel cell systems and to enhance national security and independence when these systems are initiated.

To ensure the most effective investment of Federal funds, the ERDA fuel cell category is divided into the following six project areas:

1. Utility Demonstrations

A technology assessment has shown that the phosphoric acid technology is ready to proceed toward a demonstration near the end of 1978. This will place a 4.8 MW system in a utility grid and will allow the achievement of early operating experience in the user environment.

The ongoing activity involves design, fabrication and delivery of a 4.8 megawatt module demonstrator. This phase of the project was initiated in FY 1976 and will be approaching completion in FY 1978. The next phase will involve installation of the demonstrator at a host utility and integration of the fuel cell powerplant's output into the existing utility grid. Characterization of the system's response to normal and abnormal variations in load requirements, performance efficiency, maintenance requirements and failure modes will establish design criteria for full-size generators. The FY 1978 funding will allow completion of the design and fabrication of the 4.8MW hardware and initiation of the evaluation program on a utility grid.

4.8 MW Fuel Cell System Demonstrator Program	Location: To be determined	TEC	Cumulative Prior Year		FY 1977 Estimate		Revised Estimate FY 1978		Cumulative Future Year	
			B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
ERDA Funding										
Operating Expenses		$33,000	$2,500	$2,500	$13,500	$11,800	$16,500	$15,400	$500	$3,300
a. Design & construction		10,200	0	0	900	900	9,300	8,300	0	1,000
b. R&D and operational		22,800	2,500	2,500	12,600	10,900	7,200	7,100	500	2,300
Capital Equipment		0	0	0	0	0	0	0	0	0
Total ERDA Funding		$33,000 a/	$2,500	$2,500	$13,500	$11,800	$16,500	$15,400	$500	$3,300
Host Utility Funding		$ 1,000	0	0	1,000	1,000	0	0	0	0
EPRI Funding*		7,500	300	300	2,400	2,400	3,600	3,600	1,200	$1,200
UTC Funding**		12,000 b/	800	800	5,700	5,700	5,500	5,500	0	0
Total Project Funding		$53,500	$3,600	$3,600	$22,600	$20,900	$25,600	$24,500	$1,700	$4,500

a/ Based on signed contracts to date plus estimates for siting, testing and spares
b/ Contract, Request for Proposal
* Electric Power Research Institute
** United Technologies Corporation

2. First Generation Technology

Additional phosphoric acid research is underway with the specific purpose of lowering the initial system cost to the user and further increasing system reliability.

Specifically, these activities are concerned with verification and/or modification of existing models of cell decay and development of advanced fuel cell elements. By increasing the performance and reliability and lowering the cost, the market penetration of these first generation fuel cell systems will be further increased, thereby increasing the energy resource savings and increasing taxpayer benefits.

3. Second Generation Technology

The objective of this work is to advance the state-of-the-art of molten carbonate fuel cells in order to achieve the earliest possible commercialization of these coal fueled, base load systems.

The most promising of the second generation technologies is the molten carbonate system. Studies show that it has the potential of being the most economical coal using technology in the 1980's. Work is now in progress with the objective of bringing molten carbonate fuel cell generators into commercial use by the mid 1980's, with a wide base of manufacturing capability. Compared to first generation fuel cells which use phosphoric acid as an electrolyte, the second generation cells will provide an increased electrical efficiency of approximately 50% versus an efficiency near 38% for first generation systems. Second generation fuel cells will not require precious metal catalysts, nor will their fuel processing be as complex and expensive as is required for first generation cells. The successful completion of activities in this project area will provide the manufacturers of second generation fuel cell systems with an adequate base of technology to warrant the investment necessary to manufacture systems of attractive cost and efficiency which have the capability of operation on a wide range of fuels including coal.

In FY 1977, this project area will concentrate on formulating a technology team consisting of industry, two national laboratories, and a not-for-profit institute. This team will identify the state-of-the-art and initiate multifaceted programs to arrive at the earliest possible commercialization date. During FY 1978, a request for proposals is expected to be let to design and fabricate test equipment for molten carbonate fuel cell stacks. After this time period, various molten carbonate stacks will be tested for performance and endurance, followed by a large prototype design and demonstration. Commercialization is expected by the mid to late 1980's with 800,000 barrels of oil per day saved by 1990.

4. Fuels Utilization

This project is designed to broaden the spectrum of fuel cell acceptable fuels to include the economic usage of No. 1 through No. 6 fuel oils, coal, and solid wastes. Also, this project is an enabling technology effort aimed at investigating methods of broadening the range of fuels which can be utilized by fuel cell power plants. Specifically, the efforts are aimed at extending the fuel limits primarily to higher molecular weight liquid fuels and to higher sulfur fuels. In addition, optimization studies of possible fuel cell stack-fuel process subsystem combinations will be initiated with the objective of providing guidance to the beginning of the technology program for second generation fuel processors using coal.

FY 1978 Tasks will involve an increased level of effort in transient and life testing of advanced steam reforming and catalytic partial oxidation techniques applied to higher molecular weight fuels, the evaluation of selected poison guards, and detailed studies of systems total heat integration and utilization.

5. Systems Development

The Systems Development project mission is to develop fuel cell systems for specific applications as the last step toward demonstration and commercialization. Potential applications include: (a) the efficient recovery of waste fuel sources such as waste hydrogen from industrial processes, hydrogen rich gases generated from urban waste and sewage sludge and methane-air mixtures recovered from deep shaft coal mines; (b) development of fuel cell powered integrated energy systems for residential and commercial buildings and industrial applications; and (c) development of fuel cell power plants for use in the transportation sector.

The FY 1976 efforts identified fuel cells as the most promising prime mover for integrated energy systems with high associated savings. It has also identified a technical development program leading to commercialization. The FY 1977 efforts will concentrate on overall system design and a concentrated technology program to improve reliability and cost of a 40KW fuel cell power plant. The FY 1978 efforts will continue research and development of the 40KW fuel cell system. Design and fabrication of the first proof-of-concept 40KW demonstration units for buildings and industrial applications will begin in FY 1979.

The FY 1976 and FY 1977 programs in the area of waste hydrogen utilization are directed toward identifying the primary sources of waste hydrogen. Also, a system design has been completed and sub-components fabricated and tested for a recovery system in the chemical industry in which a source of waste hydrogen and a demand for high current DC power are available. The FY 1978 program will fabricate and test a 120KW unit for this application.

A contract to build first generation fuel cell competition, directed at the electrowinning industry, will be continued.

6. Applied Research

The objective of this project is to evaluate the potential of advanced fuel cell concepts such as direct oxidation fuel cells and solid oxide electrolyte fuel cells through technology efforts aimed at solving materials problems associated with these concepts. In addition, a continuing program of research, both fundamental and applied, will be carried out on such topics as materials, catalysis, electrode polarization, etc., with the objective of achieving fuel cell improvements or hopefully, significant breakthroughs.

The above project area objectives address and improve the basic characteristics that make fuel cells attractive; namely: (1) high system efficiency that is invariant over a wide load range; (2) easily dispersed exhaust products of carbon dioxide, water, and relatively low temperature waste heat; (3) absence of a need for cooling water; and, (4) a modular design that permits flexibility in siting, sizing, construction and maintenance.

In conclusion, achievement of the fuel cell category objectives will enable ERDA to build an expanded base in fuel cell technology, advance fuel processing for various oils and coal use, demonstrate present technology, and bring the state-of-the-art into commercialization and installation in the public domain. State-of-the-art scientific knowledge and engineering technology will be publicly available to any industrial organization wishing to exploit it commercially. This will enable the country to experience the energy saving potential of an exceptionally promising technology at an affordable cost.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
B. Heat Cycles	B/A	$1,850	$11,800	+ $9,950
	B/O	1,250	7,290	+ 6,040

The Heat Cycles category consists of two major efforts; components and heat engines, and heat utilization.

1. Components and Heat Engines

The mission of the Components and Heat Engines effort is to provide for development of new energy conversion equipment based on advanced heat engines and to provide for higher efficiency and increased cost effectiveness of this equipment. Projects will be conducted to increase the fuel flexibility, efficiency, and reliability of the subsystems and components used in energy conversion and delivery systems.

They address the Nationwide requirement to find economically viable substitutes for petroleum base fuels and to improve the thermal efficiency of energy conversion methods. The tremendous potential offered by increased conversion efficiency becomes evident when it is observed that for each one point efficiency increase in equipment used Nationwide, a savings of 184,000 barrels of oil per day could be achieved (0.37 Quads). This calculation is based on historical usage figures and extrapolates to over 300,000 barrels of oil per day for each percentage point gained by the 1985 time frame.

The R&D activities in the Components & Heat Engines effort will focus on six project areas, three in advanced components and three in heat engines as delineated in the following paragraphs:

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a. High Temperature Power Conversion: Efforts were started in FY 1976 to evaluate the use of rotary expanders as the critical component of advanced power generating systems offering the greatest potential for durable operation at temperatures in excess of 2500°F with the greatest range of low grade fuels. These components, when developed and incorporated into an advanced combined cycle utility plant, could achieve total plant conversion efficiencies in excess of 50%. In FY 1976, two projects were initiated, each focusing on a different approach to an expander development; an uncooled ceramic Lysholm screw concept, and a highly cooled Roots type expander concept. Progress through FY 1977 consisted of design and internal flow and heat transfer analysis. Of the two projects, the Lysholm helical screw expander offered the most potential because the low centrifugal stresses and relative simplicity showed it to be compatible with the mechanical and thermal properties of currently available ceramic materials. Thus, its projected performance and durability with contaminated combustion products is sufficiently promising to proceed with experimental evaluation of a subscale 70KW machine in FY 1979. The FY 1978 budget increase in this project will be required for design, fabrication, and preparation for the FY 1979 hot tests.

b. Industrial/Commercial Components: An effort was initiated in FY 1976 to provide a technical assessment of energy inefficiencies in the pumping techniques of fluids. This study effort is targeted for completion in FY 1977 and the results will be used in planning future component work in the highest payoff areas identified. Funding increases will be required in FY 1978 to allow for any pursuit of promising concepts. An energy savings analysis has indicated that improved pump technology has the potential for near term (1985) energy savings of 85,000 barrels of oil per day. The FY 1978 project plan also calls for initiation of new component development programs which will directly support the advancement of improved heat pumps. This program will be coordinated with other Conservation Divisions (specifically Building and Community Systems Division) to supply them with the advanced R&D technology base needed for ultimate fullscale development of these systems. In FY 1978, the merits of several different approaches for heat pump systems will be evaluated. Initial efforts in FY 1978 will be directed toward developing a component technology base necessary to permit future prototype evaluation of the most promising advanced systems. An example of such a component is the unitary-rotary combination compressor-expander circulator in conjunction with an air to air heat exchanger.

c. Engine Components: The use of small combined cycle systems for remote power generation, inplant cogeneration, and total energy systems will require high efficiency, low cost, reliable, small steam turbines. Currently small steam turbines are costly and inefficient. It is planned to initiate work in this area in FY 1978 in response to the expressed R&D needs of the Division of Industry Conservation. The effort will focus on establishing a technology base to permit cost effective design and fabrication of highly efficient steam turbines in the 2000 to 6000 hp range. In response to specific requests, FY 1978 projects are planned in the areas of small turbine engine components and improved Stirling engine heater head and seal designs. In addition, continuation of an NSF transfer program concerned with water cooled turbine blade technology is anticipated.

d. Open Cycle Brayton: The primary demand for large industrial gas turbines will be for replacement of deferred coal and nuclear capacity and repowering of older inefficient oil fired plants which cannot be economically converted to coal. Highly efficient gas turbines in small sizes capable of durable operation with a maximum range of fuels are promising candidates for advanced total energy systems in buildings and community applications, for in-plant combined steam/power generation by industry, and for a variety of energy efficient needs such as dispersed power generation, railway or ship propulsion and pipeline pumping.

Benefits accruable by the use of highly efficient gas turbines in these applications can be measured directly in terms of fuel savings. By way of example, for large utility gas turbine combined cycle plants, the results of technical and economic analyses have identified a potential savings of over 300,000 barrels of oil per day by the late 1980's with potential savings through the 1990's projected to be over 500,000 barrels per day. To cite a single example for smaller gas turbines, more equivalent fuel is consumed in pipeline pumping alone than by all of commercial aviation. Of equal importance is the fuels flexibility afforded by this technology. Substitution of lower grade petroleum or fuels derived from waste products in industrial gas turbines is an effective form of fuels savings because it can reduce competition for light distillate which is essential to other critical end use areas such as home and institutional heating.

A project to develop the critical compressor and turbine technology for a small 10MW near term gas turbine has completed the design analysis phase; the resulting design reduces the number of turbine parts by over 80% and increases the current efficiency values by 20%. This program will move into the component design and experimentation phases in FY 1977. In FY 1978, significant funding commitments will be required to move this project into the technology readiness demonstration phase. This new conversion device will be ready for commercialization by 1980 if the funding commitments are made and will demonstrate the necessary technology for a high efficiency, low cost, multi-fuel industrial gas turbine for electric utility peaking, general industrial, and integrated energy system applications.

A substantial effort will be initiated in FY 1978 to develop the technology necessary to achieve, by the early 1980's, production readiness of highly efficient, heavy-fuel tolerant industrial gas turbines in the 100MW size range for intermediate and base load power generating applications. In FY 1978, studies will define the R&D requirements and the related development program necessary to bring an advanced gas turbine, meeting ERDA requirements, into production readiness by the early 1980s. Although significant cooperative funding by EPRI and cost sharing by the contractors is planned, this project will require a major commitment of funds in FY 1978 and extending through FY 1982.

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e. External Combustion Engines: Inherently, the externally-fired, closed cycle Stirling system has several advantages over the more common spark ignition, diesel and gas turbine engine cycles now used in many industrial applications.

These advantages include: the highest theoretical efficiency of any heat engine, having demonstrated values in excess of 40%; relatively pollution-free exhaust; freedom from vibrations; very low acoustic noise level; low speed, high torque characteristics which are favorable for most applications; and complete fuels flexibility.

With the rising costs of imported fuels, the uncertain status and quality of synthetic fuels, and the stringent environmental pollution restrictions facing future conversion devices, the externally fired engines such as Stirling cycles may prove to be one of the most cost effective, energy conserving methods of converting thermal energy into mechanical or electrical power. Multi-fuel capability is a particularly important feature for small municipal and rural utilities and for dispersed power generation in developing territories of the U.S. In many of these applications, a variety of alternate fuel sources can be economically used in lieu of light distillate oil and natural gas which are now required for conventional engines. However, no large multi-thousand horsepower machines suitable for industrial use now exist, nor is there any significant private or federal technology effort currently underway for developing these larger class industrial machines.

A project to establish the technology for large stationary Stirling cycle engines was initiated in FY 1976. This initial effort was a low level preliminary market analysis which showed a definite potential for such machines. The FY 1977 effort is also a study but focuses on the technological and economic risks involved in a full scale engine development program and on identification of needed component development efforts. In FY 1978 an evaluation of critical engine components will be initiated.

f. New Engine Concepts: An effort was started in FY 1976 to evaluate the use of a two phase, low RPM, high torque turbine for waste heat recovery systems. The attractiveness of this engine concept is its relative simplicity and low construction costs for a variety of low grade heat recovery applications. Initial results look promising and the FY 1977 effort will further quantify the economic advantages of this concept in a variety of bottoming cycle applications and investigate the stability of the candidate working fluids at representative temperatures for extended periods of time. Funding increases in FY 1978 are necessary to allow construction and test of a small 50HP blowdown model as the initial step in experimental evaluation of the concept.

2. Heat Utilization

The Heat Utilization effort is responsible for prototype development of more efficient and reliable low, middle, and high grade heat utilization systems, such as organic Rankine bottoming cycles for application to prime movers, such as large diesel engines, industrial gas turbines and waste heat recovery systems for industrial waste heat streams. It also includes a Cogeneration program which provides for dispersed power generation for industrial/commercial/residential complexes utilizing waste heat for process heat, process steam, hot water, and space heating requirements.

The Federal role involves providing the technology base and sharing the risk in capital intensive development efforts. This role is justified based on the limited incentive for private industry to invest in fuel conserving technologies. Federal involvement is essential for the planned objectives to be achieved. Because the heat utilization effort will undoubtedly lead to new technologies that require long lead times, private industry will not make heavy investments for system development which does not reflect a return on investment within three to five years.

Four major effort areas have been established:

a. Low Grade Heat Utilization: Low grade heat utilization covers technology suitable for application to heat sources with temperatures of 200° F and less. This effort is directed at utilizing the very abundant, replenishable energy from low temperature sources such as oceanic, geologic, unfocused solar, and waste heat from industrial processes and power production. It has been estimated, for example, that approximately 6,000MW of thermal energy from conventional and nuclear power plants is available as a potential source of recoverable low grade heat. Industry, users of more than 40% of the total energy consumed in the Nation, currently rejects approximately 50% of its required energy input in the form of waste heat. Recovery of a fraction of the waste heat resources could have a significant impact on the Nation's energy posture.

   The low grade heat utilization effort is planned to accomplish the following basic objectives which are directly related to ERDA National goals: elimination of avoidable energy losses to reduce energy consumption; improvement in the efficiency of existing and future energy converters; and, development of alternate energy sources to reduce both consumption rate of domestic fuel sources and importation rate of foreign fuels.

In FY 1976, a six month technology assessment effort was initiated to develop a profile of energy consumption and waste heat availability by industrial category via an assessment of pertinent technology and systems appropriate to the subject temperature ranges. It is planned to use the results of this effort as a basis for the determination of high payoff areas for utilization of the low grade waste heat. FY 1977 will include a minimal effort as a follow up to this study. Plans will be made to implement the results of the FY 1976 study to, if necessary, redirect selected R&D efforts in FY 1978 and in FY 1979 to address those identified high payoff applications requiring technology beyond the current state-of-the-art for successful implementation.

FY 1977 new starts include a project designed to identify the requirements and related information necessary for determining suitability and technical and economic feasibility of viable applications, both on-site and off-site, for optimum utilization of the low temperature waste heat currently rejected by uranium enrichment gaseous diffusion plants. Program planning in this area is being coordinated with ERDA's nuclear programs. Emphasis will be accelerated in FY 1978 based on the results and recommendations from the FY 1977 efforts. It is expected that the very abundant replenishable sources (5400MW total of low grade heat at three sites) which will be increased via a capacity uprating program for the plants by the early 1980's, will develop into a full scale multimillion dollar effort. With proper attention and appropriate funding, this effort alone can result in potential savings equivalent to approximately 20,000 barrels of oil per day. Currently there is no heat cycle technology base for low temperature (200° F), high efficiency conversion machines. It is intended in FY 1978 to initiate a program addressing evaluation and conceptual design of candidate heat engines in this low temperature range. The most promising concepts will be selected and further design and development studies conducted in the later part of FY 1978 and FY 1979. The overall objective of this project is to provide the needed technology base in low temperature heat engines in support of waste heat recovery systems.

b. Middle Grade Heat Utilization: Middle grade heat falls within a temperature range from 200° F to 1000° F. The major effort in this area is the development of technology for organic Rankine systems for bottoming cycles and for industrial waste heat recovery. These systems will allow existing large diesels and gas turbines to be operated at efficiencies up to 10 percentage points higher than at present. This will represent an approximate 1/3 increase in output at no additional capital cost or a 1/3 decrease in fuel usage for the same output. These systems are a prime candidate for near-term implementation since they are suitable for retrofit and can be commercially available in less than five years and will have a return on investment of 20% or better.

The FY 1976 project initiated a first of a kind contract combining cost sharing and incentives for development of an organic Rankine cycle for near term commercialization. This and another competing concept were initiated to design, develop and field test units combined with diesels of a public utility and a municipal power plant. Funding in FY 1978 is required to allow these projects to continue into the more expensive engineering development phases consistent with established schedules.

c. High Grade Heat Utilization: High grade heat utilization applies to heat streams in the range of 1000° F and higher. This category can be further divided into the use of high temperature primary heat, such as utilizing the high heat of combustion of coal in an electric power generating plant, and the use of high temperature waste heat, such as the millions of BTUs that are vented to the atmosphere in energy intensive industries.

In FY 1976, experimental efforts were initiated to investigate the feasibility of topping a coal fired electric power generating plant with thermionic conversion devices. Thermionic conversion devices directly convert high temperature heat into electricity and can reject their waste heat directly into the basic steam cycle. Combined plant conversion efficiencies of over 50% are possible. These efforts are a cooperative program with ERDA's Division of Nuclear Research and Applications. The FY 1976 efforts have shown promising improvements in performance levels of thermionic devices, and initial development of large scale converters. The FY 1977 and FY 1978 efforts will be focused at improved performance levels, system studies to analyze different plant configurations, and material and hardware development leading to an in-boiler demonstration by 1980.

d. Cogeneration: Traditionally, the utility and industrial/residential sectors have been isolated entities in the U.S. economy. Power plants have been optimized for electrical production with very low quality waste heat rejection, while direct heating, process steam, space heating and similar heat requirements have been produced in furnaces on the industrial/residiential site. There is a growing body of evidence, however, that small generators which simultaneously produce electrical and thermal energy in dispersed generation systems or cogeneration systems can be a less capital intensive, more efficient, and more environmentally benign approach to power generation than large, central station nuclear or fossil plants. Such are ideally applicable to industrial parks with a mix of facilities requiring electrical power and process energy and which also exhaust substantial recoverable waste energy. Moreover, these concepts are amenable to a high degree of fuel flexibility and the complexity of the distribution system is reduced. This program represents a major effort but has extremely high potential for saving energy. Studies conducted by ERDA have shown that over 180 million barrels of oil per year could be saved by integrating electrical power production and process heat production in small power plant systems located at industrial and/or commercial residential sites. The concept of selling both electricity and heat from the same device with the same fuel is inherently attractive. Both Sweden and West Germany have made extensive use of the concept. The FY 1978 effort will initiate an examination of the approaches to modifying those driving and retarding forces (such as institutional barriers) that directly

CONSERVATION RESEARCH AND DEVELOPMENT
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impact the implementation of the cogeneration concept. A program will also be initiated to address technical problems that include the opportunities for cogeneration and the various options such as topping, bottoming, and combined cycles.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
C. Combustion	B/A	$850	$7,200	+ $6,350
	B/O	580	5,960	+ 5,380

The purpose of the Combustion category is to provide advanced technology necessary to increase efficiency and to utilize alternate fuels in combustion equipment. This applied research and technology development effort generally is concerned with all classes of combustion equipment. However, the efforts are directed primarily toward applications with the greatest potential for conservation of energy and critical fuels.

Combustion applications account for nearly 90% of the total fuel utilization in this country. The applications with high conservation potential are responsible for most of this fuel utilization. Consequently, the impact of advanced combustion technology expected to result from this category will be substantial in terms of reduction of usage of total energy and critical fuels. A recently completed energy savings analysis indicated that this technology can save over 200,000 barrels of oil per day by 1985.

The Combustion category is pursuing solutions involving improved or alternative combustion equipment. The justification for pursuing these classes of solutions consists of three elements:

1. Improved or alternative combustion equipment will provide energy and critical fuel conservation without reductions in equipment utilization.
2. Improved or alternative combustion equipment will provide conservation benefits in the near future.
3. Improved or alternative equipment will provide conservation benefits without major modifications of energy conversion equipment and fuel supply systems.

In short, the solutions being pursued offer near-term benefits with minimum impact on existing energy systems and on the United States lifestyle.

The general approach followed in solving the problem of high energy consumption by combustion equipment involves two elements:

1. Development of advanced engineering design methods, and
2. Development of advanced combustion equipment design concepts.

This approach to problem solving involves two factors which make it necessary for the Federal government to take an active role. These factors are the need for advanced research capabilities and the need to undertake high risk ventures in advanced design concepts.

The research capabilities necessary to develop advanced engineering design methods and concepts are not generally available in the combustion equipment industry. These capabilities include scientists and engineers with experience in both theoretical and experimental aspects of combustion research, specialized laboratory equipment including combustion diagnostic instruments and computers, and access to operational combustion equipment. These capabilities must be drawn jointly from university, industrial and government laboratories and utilized in a comprehensive and coordinated research program. Such a program can best be formulated and implemented by a Federal agency.

The risks involved in investigating new combustion equipment design concepts stem from the requirements for facilities and equipment, making the process costly and time consuming. Combustion equipment manufacturers, in general, conduct limited technology development activities devoted primarily to modifications of existing product lines.

To take full advantage of the research capability which exists in the United States and to pursue the large number of advanced concepts which also exist, a vigorous combustion program is required, supported by the Federal government. Only through such a program will the potential benefits of advanced combustion technology be obtained.

In response to the need for Federal involvement, a detailed plan has been prepared and is being implemented. The plan has been distributed for review by representatives of the combustion equipment industry and the research community, and the responses from these reviews have been unanimously enthusiastic and supportive of the program. Efforts on advanced design methods, advanced technology concepts and advanced technology utilization have been initiated in seven subcategories of technological systems with high conservation potentials.

1. Internal Combustion Engine Combustion Components

The objective of the Internal Combustion Engine Combustion Components effort is to develop advanced technology for reducing fuel consumption and environmental impacts through control of combustion processes. Effort is directed toward four engine classes: (a) homogeneous charge (conventional), (b) stratified charge, (c) divided chamber, and (d) diesel.

Accomplishments to date include development of advanced measurement techniques for monitoring combustion processes in these engines. In FY 1977, a number of advanced concepts for combustion component design are being evaluated, and a cooperative government-university-industry project has been initiated to facilitate the transfer of these accomplishments to the automotive industry. This cooperative project is supported jointly by the Improved Conversion Efficiency Program and the Heat Engine Highway System Program. In FY 1978, the entire effort in this subcategory will be expanded to increase the number of advanced concepts under evaluation and to accelerate the development of advanced design methods.

2. Gas Turbine Combustors

The objective of the Gas Turbine Combustor effort is to develop combustor design technology for (a) operation at higher turbine inlet temperatures, (b) reduction of pollutant emissions, and (c) operation with alternate fuels. Effort is directed toward control of combustion processes in conventional combustors and unconventional combustors such as catalytic and surface combustors. Potential applications include stationary, automotive, and aircraft gas turbines. In FY 1976 and FY 1977, effort in this subcategory has been limited to an assessment of technology needs and to development and application of advanced measurement methods for combustion processes in gas turbine combustors. In FY 1978, effort will be initiated on the development of improved combustor design methods. These design methods will include mathematical analysis techniques and supporting data for facilitating the design of improved combustors of both the convential and unconventional types.

3. Boiler and Furnace Burners

The objective of the Boiler and Furnace Burner effort is to develop advanced burner design technology for (1) operation at low excess air rates and (2) operation with alternate fuels. Effort is directed primarily toward burners for residential and commercial applications using liquid and gaseous fuels. A limited effort under this subcategory was initiated in FY 1977 with an analysis of advanced technology requirements. In FY 1978, additional effort will be initiated on development of improved burner design methods and evaluation of new design concepts.

4. Industrial Process Burners

The objective of the Industrial Process Burner effort is to develop advanced burner design technology for (a) operation with high inlet air temperatures (for waste heat utilization) and (b) operation with alternate fuels. Primary effort is directed toward natural gas burners and secondary effort toward other industrial burners. A limited effort under this subcategory was initiated in FY 1977 with an analysis of advanced technology data requirements. In FY 1978, additional effort will be initiated on development of improved burner design methods and evaluation of new concepts.

5. Alternate Fuels Technology

The objective of the Alternate Fuels effort is to develop technology for direct combustion of alternate, non-fossil fuels, including biomass fuels, municipal and industrial wastes, and fuels derived from these sources. New technology being developed includes (1) characterization of combustion behavior of alternate fuels and (2) development of design guidelines for alternate fuel combustion equipment. In FY 1976 and FY 1977, limited efforts were initiated in this subcategory including an analysis of fuel characterization requirements and an investigation of combustion characteristics of wood residues. In FY 1978, a broad program will be initiated to evaluate alternate fuels and fuel modification methods.

6. Fuel Processing, Transport and Storage Technology

The objective of the Fuel Processing, Transport, and Storage Technology effort is to develop improved technology to reduce fuel utilization and losses in the natural gas and petroleum processing and supply network. The effort includes development of analytical models of unit and combined processes, and use of models to develop improved equipment design guidelines and operating procedures. This effort will be limited in FY 1978 to an analysis of technology requirements and initiation of a fuel transport system modeling study.

7. Coalbed Methane Conservation

Approximately 250 million cubic feet of methane, the major constituent of natural gas, is vented to the atmosphere daily during coal mining operations. It is estimated that U.S. coal reserves contain approximately 300 trillion cubic feet of methane which could be recovered and utilized. This potential energy source is equal to a ten to twelve year supply of natural gas. Thus, the objective of the Methane from coalbed subcategory is to bring about a set of conditions wherein the conservation of coalbed methane is clearly to the economic advantage of the relevant private sector interests, and which minimizes the necessity for Federal involvement in the longer term. Also included in this effort will be the recovery of methane from contaminated and shut-in gas wells. The FY 1977 efforts include studies initiated in FY 1976 leading to demonstration options as well as investigating the legal gas ownership question. The FY 1978 budget request will provide for the initiation of a limited number of near-term development/demonstration projects for recovering and utilizing methane from coalbeds and start efforts to quantify the amount of gas available from other sources such as contaminated and shut-in gas wells.

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
D. Supporting Technologies For.....	B/A	$1,450	$8,000	+ $6,550
End Use Applications	B/O	1,170	5,050	+ 3,880

CONSERVATION RESEARCH AND DEVELOPMENT
END USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - continued

The Supporting Technologies For End Use Applications Category provides the necessary long term research and development services to the Improved Conversion Efficiency Subprogram, other elements of the Conservation Research and Development Program and other ERDA programs in the areas of thermodynamics and heat transfer technology, materials and fabrication technology, and controls and process efficiency. Supporting technology efforts are coordinated with other ERDA Programs through formal coordinating committees. Additionally, this category provides the requisite planning and analysis support to the Improved Conversion Efficiency Subprogram.

The necessity to conduct this activity is based upon the need to provide the requisite technology base for the eventual implementation of future energy conversion systems. Since the efforts involved are generally high-payoff, high-risk types, with little realizable impact in the near term, a strong Federal role is required.

1. Thermodynamics and Heat Transfer

The overall objective of the Thermodynamics and Heat Transfer effort is to provide the relevant technology base required for the ultimate implementation of advanced energy systems designed to reduce the Nation's dependency on foreign energy imports. Approximately 20% of the Nation's energy consumption eventually winds up as industrial waste heat. Additional quantities of energy are rejected into the atmosphere from vehicle heat engines and building heating, ventilating and air conditioning systems. Advanced technology in heat exchangers and thermodynamics is necessary to allow conversion of this resource to useful energy forms.

Specific objectives being addressed are as follows:

- Increase upper temperature limit capability of heat exchangers to greater than 2000° F.
- Increase heat transfer efficiency by up to 50%.
- Decrease heat exchanger costs by as much as 50%.

FY 1976 efforts were limited to completion of a heat exchanger technology assessment and preparation of a program plan. In FY 1977, selected, high priority projects as outlined in the plan will be initiated on a limited basis. These include: research in flow induced heat exchanger tube vibration being conducted as part of an overall International Energy Agency Program; ceramic heat pipe and ceramic heat exchanger development for high temperature applications in a joint program with the Electric Power Research Institute; experimental research on the causes and effects of heat exchanger fouling and corrosion, and the evaluation of fluidized bed heat exchanger concepts for waste heat recovery. The FY 1978 funding increase will allow new starts in the evaluation of alternate fluids for heat pipes; heat transfer enhancement; concepts for direct contact heat exchangers and residential flue gas heat recovery; and in Thermodynamics, advanced working fluid development for bottoming cycles, and a Rankine cycle design handbook.

2. Materials and Fabrication Technology

A broad-based materials research and development effort is a vital part of the Nation's energy program. Virtually all of the engineering projects which make up the energy program require important contributions from the materials community. The nature of the contributions varies from project to project but can generally be placed into one or more of the following areas:

- Provide materials and fabrication techniques to meet design requirements of engineering systems
- Ensure that materials used in engineering hardware will not fail prematurely or catastrophically
- Find the low-cost substitutes for expensive materials and fabrication techniques to meet cost requirements of engineering systems
- Solve problems related to availability of materials in short supply
- Find methods to predict and extend the service life of materials subjected to extreme environments
- Implement improvements in the materials production and fabrication industries for conservation of both materials and energy
- Develop an understanding of materials behavior when used in critical components of engineering systems

In FY 1976, this effort played a major role on the Committee on Materials (COMAT) of the Federal Council on Science and Technology. This Committee has completed a detailed analysis of the near, mid and long term requirements for R&D in energy related materials. This plan has been published by the Materials and Fabrication efforts under ERDA title. In response to the requirements identified in this study, projects have been initiated in this effort for FY 1977 with anticipation of expansion during FY 1978. The technology base will be developed to the point where component evaluation can proceed.

The following efforts will be undertaken in FY 1978.

a. High Temperature Materials. State-of-the-art materials are now operating near their maximum useful temperature limit. It is the purpose of this effort to develop promising new materials for high temperature energy system applications. Current efforts center on ceramic materials and their fabrication for use in advanced heat engines including higher temperature gas turbines.

b. Polymers and Reinforced Plastics. Polymeric materials derived from petroleum and natural gas have been widely used in recent years. Energy conservation and use aspects of polymers are being examined by this effort, such as alternate feedstocks, waste recovery and conversion, and efficient utilization in energy systems. FY 1978 funding will be used to continue study projects.

c. Advanced Development, Planning and Analysis. Studies are continuing to define the proper areas for emphasis in the materials area and to assess the environmental and other impacts of new materials.

3. Controls and Process Efficiency

The overall Controls and Process Efficiency objectives are established in conjunction with the Industrial Energy Conservation Subprogram and are as follows:

- To provide engineering information in the form of diagnostic and design techniques for improving the control, efficiency and reliability of existing processes and for accelerating the advancement of technology, and
- To effectively disseminate this information to the engineering community so as to expedite its utilization.

Until recently, the relatively low price of energy did not usually provide sufficient economic incentives for the upgrading of inefficient processes. The investment related to the research, development and implementation of diagnostic procedures and equipment to evaluate processes and control procedures and equipment to facilitate efficient operation often outweighed the economic benefit to be gained. Consequently, there exists today significant potential for energy savings in upgrading these inefficient processes.

The FY 1977 efforts will concentrate on R&D of a cavitating hydrojet technique for descaling boiler tubes, (energy savings of 30,000 barrels of oil per day are estimated) and on an Engineering Methods--Industrial Requirements program planned in collaboration with small business through a Program Research and Development Announcement (PRDA). Projects derived from this PRDA will provide engineering information including instrumentation, experimental data, and computer codes in fields of friction, fluid mechanics, unit operations, unit processes and controls in response to priorities set by energy intensive industries for meeting ERDA's goals. An instrument to measure temperatures of 2000-3000° F in molten iron will be developed to enable detailed analysis and control of cupola operation.

The increased funds available in FY 1978 will be used to initiate efforts to provide engineering information leading to the commercialization of foil-gas bearings required for practical automotive turbines and economical waste-heat utilization; traction drives for many applications including economical waste-heat utilization and synfuel/syngas processes; and techniques of design for reducing wear in machinery.

4. Planning and Analysis

The Planning and Analysis effort supports all four research and development categories within the Improved Conversion Efficiency Subprogram.

Planning and Analysis conducts the subprogram's project appraisals, technology assessments, and planning. The establishment and maintenance of this effort are justified as follows:

- Proper integration of the component categories of Improved Conversion Efficiency Subprogram to allow the constant pursuit of National goals calls for a centralized planning function.
- The analysis requirements resulting from ERDA's planning, programming, budgeting and review system are best met through the efforts of a single planning team.
- The Program appraisal process serves as a mechanism by which the Improved Conversion Efficiency program manager can allocate resources--money, manpower, and time--judiciously.

With respect to the last justification, the need for control is especially acute within this subprogram because of the wide range of supporting technology that is provided to a diverse group of programs throughout nearly all of ERDA's technology areas. In the absence of a methodical, continuous study of old and new projects, the subprogram could allocate its resources inefficiently and thereby jeopardize the progress of other programs dependent upon this effort.

In FY 1976, efforts were initiated to establish a program appraisal methodology and to conduct the technology assessments and cost-benefit studies necessary to properly evaluate projects in this subprogram. In FY 1977, the program appraisal methodology will be fully implemented, and cost-benefit studies will be conducted on current effort areas. An increase in FY 1978 funding levels is necessary to conduct studies and appraise the expanded efforts planned for FY 1978.

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Plant and Capital Equipment
(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT

END USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	Revised Estimate FY 1978
A - Obligations for Construction Projects.....	$ 0	$ 0	$ 0	$ 0
B - Obligations for Capital Equipment Not Related to Construction.....	270	183	2,187	1,670
Total Obligations for Plant and Capital Equipment.	$ 270	$ 183	$ 2,187	$ 1,670

Obligations for the End Use Conservation and Technologies to Improve Efficiency Program for FY 1978 are estimated at $1,670,000 of which:

a. $0 is for construction projects.

b. $1,670,000 is for Capital Equipment Not Related to Construction justified in Section B below, requested for authorization in the proposed Authorization Bill.

SECTION B - Obligations for Capital Equipment Not Related to Construction

Subprogram	Actual FY 1976	Actual TQ	Estimate FY 1977	Revised Estimate FY 1978
1. Industrial Energy Conservation.....	$ 0	$ 0	$1,000	$ 500
2. Buildings and Community Systems.....	0	0	0	170
3. Transportation Energy Conservation.....	133	120	687	500
4. Improved Conversion Efficiency.....	137	63	500	500
Total End Use Conservation and Technologies to Improve Efficiency.....	$ 270	$ 183	$2,187	$1,670

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(Dollars in thousands, except where dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
END USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

JUSTIFICATION

1. Industrial Energy Conservation.....$ 500

The purchase of long lead items of capital equipment within the Industrial Process Efficiency category needed for demonstration hardware to demonstrate coal in aluminum remelt operations during FY 1979 will require an estimated $500,000 during FY 1978. The related FY 1979 activity will include a demonstration of a full scale aluminum remelt operation using coal as a fuel instead of natural gas. The $500,000 in capital equipment will be provided by the Federal Government with provision for buy back by the end user industry following a successful demonstration.

2. Buildings and Community Systems.....$ 170

A major end product of an RD&D undertaking by the conservation program is the collection, analysis, and dissemination of data. In order to collect and analyze this data, certain capital equipment items are required: collection, instrumentation, testing equipment, data reduction equipment, basic laboratory equipment, etc. Specific equipment will be required to conduct heat pump seasonal performance measurements and test apparatus is needed to perform verification analysis on various lighting systems and building controls systems. Demonstrations data verification through instrumentation and sensing devices will be undertaken to validate demonstration assumptions. Additionally diverse instrumentation and advanced technology components and monitoring systems are essential to support various integrated community energy systems efforts.

3. Transportation Energy Conservation.....$ 500

It is planned to procure seven prototype General Motors gas turbine engines at an approximate cost of $70,000 each for a total of $500,000. These gas turbines will be installed in buses purchased by DOT for a joint DOT/ERDA evaluation program. This program will place the turbine engine buses in selected localities allowing an accumulation of data from actual urban operating conditions. This data will then be used in the gas turbine engine development program.

(Dollars in thousands, except whole dollars in narrative material)

CONSERVATION RESEARCH AND DEVELOPMENT
END USE CONSERVATION AND TECHNOLOGIES TO IMPROVE EFFICIENCY - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

4. Improved Conversion Efficiency.....$ 500

Capital equipment not related to construction is required to purchase experimental hardware in support of applied research and technology development efforts underway in the Improved Conversion Efficiency subprogram. Major requirements are in the areas of diagnostic instrumentation for the Combustion category and experimental equipment required for testing molten carbonate fuel cell stacks. Additionally, minor expenditures for diagnostic and experimental equipment will be required in the Supporting technology areas of controls and process efficiency and thermodynamics and heat transfer.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates

(Dollars in Thousands)

SUMMARY TABLE BY SUBPROGRAM

Fossil Energy Development

Operating Expenses

	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
Coal											
1. Liquefaction	$ 97,884	$100,289	$ 55,822	$ 26,380	$ 47,490	$ 24,843	$ 72,957	$ 81,015	$ 84,983	$ 107,000	$109,800
2. High-Btu Gasification	53,364	45,566	48,850	9,250	12,037	13,680	44,054	53,021	58,704	51,200	42,800
3. Low-Btu Gasification	24,552	29,433	19,031	6,720	3,513	4,940	33,052	56,041	39,952	73,900	47,200
4. Advanced Power Systems	10,001	10,619	2,737	3,500	2,089	2,723	22,500	23,715	12,800	25,500	23,800
5. Direct Combustion	46,096	30,109	17,951	13,500	26,213	6,466	51,901	74,346	56,826	53,200	56,900
6. Advanced Research and Supporting Technology	35,393	36,055	24,067	8,850	11,240	9,892	37,070	38,727	36,570	40,000	42,000
7. Demonstration Plants	27,900	6,397	10,695	7,750	- 838*	5,525	53,000	79,154	50,600	40,900	28,700
8. Magnetohydrodynamics	33,544	26,178	22,028	7,800	10,318	9,628	34,990	58,887	25,989	45,800	33,000
Total OE Coal Program	328,734	284,646	201,181	83,750	112,062	77,697	349,524	464,906	366,424	437,500	384,200
Petroleum and Natural Gas											
1. Enhanced Oil Recovery	25,700	15,418	13,935	4,646	16,016	4,471	23,782	24,913	21,682	46,100	40,100
2. Enhanced Gas Recovery	13,494	5,340	4,730	3,100	9,387	2,976	14,874	16,643	11,274	22,000	19,500
3. Drilling, Exploration and Offshore Technology	2,229	1,274	984	680	1,080	1,404	2,400	2,955	1,600	1,600	2,000
4. Processing and Utilization	1,797	1,822	1,849	450	470	489	1,831	1,789	1,831	1,400	1,400
Total OE Petroleum and Natural Gas Program	43,220	23,854	21,498	8,876	26,953	9,340	42,887	46,300	36,387	71,100	63,000
Oil Shale and In Situ Technology											
1. Oil Shale	14,985	7,780	7,024	2,250	4,714	2,486	22,278	27,020	13,323	28,000	21,500
2. In Situ Coal Gasification	6,137	6,724	8,217	1,680	1,982	2,069	8,236	8,720	6,736	11,000	12,000
Total OE Oil Shale and In Situ Technology Program	21,122	14,504	15,241	3,930	6,696	4,555	30,514	35,740	20,059	39,000	33,500
Total OE Fossil Energy Development	$393,076	$323,004	$237,920	$ 96,556	$145,711	$ 91,592	$422,925	$546,946	$422,870	$ 547,600	$480,700

* Reflects a net FY 1976 obligation adjustment between Operating Expenses and Plant and Capital Equipment made against the Transition Quarter rather than the FY 1976 period.

(Dollars in Thousands)

SUMMARY TABLE BY SUBPROGRAM - continued

Fossil Energy Development - continued

Plant and Capital Equipment	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
Coal	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
Capital Equipment											
1. Liquefaction	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 400	$ 200
2. High-Btu Gasification	0	0	0	0	0	0	100	100	50	300	200
3. Low-Btu Gasification	0	0	0	0	0	0	0	0	0	500	300
4. Advanced Power Systems	0	0	0	0	0	0	0	0	0	200	200
5. Direct Combustion	0	0	0	0	0	0	0	0	0	200	100
6. Advanced Research and Supporting Technology	0	0	0	0	0	0	0	0	0	300	200
7. Magnetohydrodynamics	0	0	0	0	0	0	0	0	0	500	300
8. Other Capital Equipment	0	0	0	0	0	0	150	150	100	0	0
Total Capital Equipment	0	0	0	0	0	0	250	250	150	2,400	1,500
Construction Projects - Total	33,000	14,740	3,875	8,000	4,600	818	59,200	80,860	21,700	86,800	34,800
Total P&CE Coal Program	33,000	14,740	3,875	8,000	4,600	818	59,450	81,110	21,850	89,200	36,300
Petroleum and Natural Gas											
Capital Equipment											
1. Enhanced Oil Recovery	100	100	2	100	9	0	100	190	80	300	200
2. Enhanced Gas Recovery	0	0	0	0	0	0	0	0	0	300	200
3. Drilling, Exploration and Offshore Technology	0	0	0	0	0	0	0	0	0	0	0
4. Other Capital Equipment	0	0	0	0	0	0	170	170	120	0	0
Total Capital Equipment	100	100	2	100	9	0	270	360	200	600	400
Construction Projects - Total	0	0	0	0	0	0	0	0	0	0	0
Total P&CE Petroleum and Natural Gas Program	$ 100	$ 100	$ 2	$ 100	$ 9	$ 0	$ 270	$ 360	$ 200	$ 600	$ 400

(Dollars in Thousands)

SUMMARY TABLE BY SUBPROGRAM - continued

Fossil Energy Development - continued

Plant and Capital Equipment - continued	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
Oil Shale and In Situ Technology											
Capital Equipment											
1. Oil Shale	$ 325	$ 200	$ 69	$ 100	$ 226	$ 150	$ 450	$ 450	$ 440	$ 900	$ 600
2. In Situ Coal Gasification	0	0	90	0	0	0	0	0	0	1,600	1,000
3. Other Capital Equipment	0	0	0	0	0	0	50	50	50	0	0
Total Capital Equipment	325	200	159	100	226	150	500	500	490	2,500	1,600
Construction Projects - Total	0	0	0	0	0	0	0	0	0	0	0
Total P&CE Oil Shale and In Situ Technology Program	325	200	159	100	226	150	500	500	490	2,500	1,600
Total P&CE Fossil Energy Development	$ 33,425	$ 15,040	$ 4,036	$ 8,200	$ 4,835	$ 968	$ 60,220	$ 81,970	$ 22,540	$ 92,300	$ 38,300
FOSSIL ENERGY DEVELOPMENT SUMMARY											
Operating Expenses	393,076	323,004	237,920	96,556	145,711	91,592	422,925	546,946	422,870	547,600	480,700
Capital Equipment	425	300	161	200	235	150	1,020	1,110	840	5,500	3,500
Construction Projects	33,000	14,740	3,875	8,000	4,600	818	59,200	80,860	21,700	86,800	34,800
TOTAL	$426,501	$338,044	$241,956	$104,756	$150,546	$ 92,560	$483,145	$628,916	$445,410	$ 639,900	$519,000

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FOSSIL ENERGY DEVELOPMENT
FY 1978 Budget Estimates
(Dollars in Thousands)

SUMMARY TABLE BY TECHNOLOGIES: BUDGET AUTHORITY

COAL PROGRAM Operating Expenses	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
Liquefaction				
a. Direct Hydrogenation				
1. Ebullated-bed (H-Coal) pilot plant	$ 27,096	$ 11,530	$ 20,800	$ 26,000
2. Fixed-bed hydrogenation (Synthoil) PDU	7,573	3,250	7,900	11,000
3. Zinc chloride catalyst PDU	2,000	860	2,400	2,000
4. Disposable catalyst hydrogenation	516	150	601	500
5. Multi-stage liquefaction pilot plant	0	0	0	1,000
Total Direct Hydrogenation	37,185	15,790	31,701	40,500
b. Solvent Extraction				
1. Solvent refined coal (SRC) pilot plant operations	20,570	3,145	19,635	15,000
2. Solvent refined coal utilization	2,020	517	1,120	1,000
3. Solvent extraction of lignite	500	0	1,000	0
4. CO-Steam process	1,000	250	500	500
5. Chemicals from coal	300	125	450	400
6. Donor solvent pilot plant	2,000	500	2,000	30,300
Total Solvent Extraction	26,390	4,537	24,705	47,200
c. Pyrolysis				
1. Clean metallurgical coke/liquids	3,400	200	2,400	0
2. Flash liquefaction	500	50	900	500
3. Entrained-bed pyrolysis	200	50	600	500
4. Hydrocarbonization/Residue carbonization	800	100	900	0
5. Fluid coke	600	100	600	1,000
Total Pyrolysis	5,500	500	5,400	2,000
d. Indirect Liquefaction	1,700	750	1,100	0
e. Support Studies and Engineering Evaluations				
1. Cresap liquefaction test facility	17,514	3,417	5,000	12,500
2. Refining	1,578	300	1,300	1,500
3. Environmental studies, other support and special projects	8,017	1,086	3,751	3,300
Total Support Studies and Engineering Evaluations	27,109	4,803	10,051	17,300
Total Liquefaction	$ 97,884	$ 26,380	$ 72,957	$107,000

(Dollars in Thousands)

Summary Table by Technologies: Budget Authority - continued
Coal Program - continued

	Actual FY 1976	Actual TQ	Estimate FY 1977	Rev. Est. FY 1978
High-Btu Gasification				
a. Development of New Second Generation Gasification Techniques				
1. HYGAS pilot plant	$ 6,370	$ 670	$ 2,800	$ 0
2. Carbon dioxide acceptor pilot plant	5,640	710	2,133	0
3. Bi-Gas pilot plant	12,000	1,200	9,800	11,000
4. Self-agglomerating burner pilot plant	3,340	807	2,227	1,500
5. Synthane pilot plant	9,000	1,400	10,500	14,500
6. Hydrane PDU	2,981	705	1,800	3,500
7. Steam-iron pilot plant	7,190	2,047	4,600	5,700
8. Catalytic gasification pilot plant	0	0	0	3,500
Total Dev. of New 2nd Generation Gasification Techniques	46,521	7,539	33,860	39,700
b. Support Studies and Engineering Evaluations				
1. Engineering evaluations	3,100	200	1,600	3,000
2. Equipment, materials and process development	0	955	4,557	4,100
3. Technology implementation support	0	0	0	1,000
4. Environmental studies, other support and special projects	3,743	556	4,037	3,400
Total Support Studies and Engineering Evaluations	6,843	1,711	10,194	11,500
Total High-Btu Gasification	53,364	9,250	44,054	51,200
Low-Btu Gasification				
a. Low-Btu Gasification Processes				
1. Fixed-bed gasification	2,350	588	2,950	4,550
2. Fluid-bed gasification, pressurized	8,300	750	1,700	5,000
3. Entrained-bed gasification, atmospheric, PDU	0	0	500	0
4. Combined cycle test facility	6,550	2,000	16,500	28,000
5. Molten salt PDU, pressurized	500	0	1,000	0
6. Hydrogen from coal facility	0	0	5,000	18,000
7. Ash agglomeration	0	0	0	1,300
Total Low-Btu Gasification Processes	17,700	3,338	27,650	56,850
b. Support Studies and Engineering Evaluations				
1. Hot gas cleanup	2,050	150	2,600	3,600
2. Gasifiers in industry	0	0	1,000	10,000
3. Environmental studies, other support and special projects	4,802	3,232	1,802	3,450
Total Support Studies and Engineering Evaluations	6,852	3,382	5,402	17,050
Total Low-Btu Gasification	$ 24,552	$ 6,720	$ 33,052	$ 73,900

(Dollars in Thousands)

Summary Table by Technologies: Budget Authority - continued
Coal Program - continued

Advanced Power Systems	Actual FY 1976	Actual TQ	Estimate FY 1977	Rev. Est. FY 1978
a. Open Cycle Gas Turbine	$ 6,835	$ 2,700	$ 16,400	$ 18,700
b. Closed Power Systems				
1. Closed cycle gas turbine/primary heat exchanger	1,050	200	1,500	3,250
2. Alkali metal vapor systems	1,191	100	1,380	250
Total Closed Power Systems	2,241	300	2,880	3,500
c. Support and Additional Programs	925	500	3,220	3,300
Total Advanced Power Systems	10,001	3,500	22,500	25,500
Direct Combustion				
a. Fluidized-bed Boilers, Atmospheric				
1. Fluidized-bed boiler, 30 MW	8,600	1,000	3,000	4,000
2. Industrial applications	1,000	2,500	10,000	10,000
3. Component test and integration unit (AFB-CTIU)	4,000	2,500	4,365	5,500
4. MIUS	2,400	0	1,700	2,000
5. Plant conversion	0	0	1,100	0
6. Anthracite applications	0	0	1,000	0
Total Fluidized-bed Boilers, Atmospheric	16,000	6,000	21,165	21,500
b. Pressurized Systems				
1. Fluidized-bed combined cycle pilot plant	4,000	0	6,000	7,000
2. Pressurized fluidized-bed technology	0	0	1,600	0
3. Component test and integration unit (PFB-CTIU)	4,896	2,300	5,100	4,729
4. Granular bed filter/hot gas cleanup	2,200	1,200	1,500	1,500
5. International Energy Administration	300	0	3,000	2,000
Total Pressurized Systems	11,396	3,500	17,200	15,229
c. Coal/Oil Slurries	6,000	2,300	4,300	7,000
d. Support Studies and Engineering Evaluations				
1. Engineering studies	5,700	1,200	5,101	4,471
2. Non-fluidized bed combustion	0	0	1,500	3,000
3. Environmental studies, other support and special projects	7,000	500	2,635	2,000
Total Support Studies and Engineering Evaluations	12,700	1,700	9,236	9,471
Total Direct Combustion	$ 46,096	$ 13,500	$ 51,901	$ 53,200

(Dollars in Thousands)

Summary Table by Technologies: Budget Authority - continued
Coal Program - continued

Advanced Research and Supporting Technology	Actual FY 1976	Actual TQ	Estimate FY 1977	Rev. Est. FY 1978
a. Materials and Components	$ 8,493	$ 1,850	$ 8,585	$ 9,264
b. Processes	14,000	4,000	15,200	16,401
c. Direct Utilization	5,000	1,000	5,535	5,972
d. Program Development and Coordination	7,900	2,000	7,750	8,363
Total Advanced Research and Supporting Technology	35,393	8,850	37,070	40,000
Demonstration Plants				
a. Clean Boiler Fuel Demonstration Plant	10,000	2,000	0	0
b. High-Btu Pipeline Gas Demonstration Plant	8,000	2,000	10,000	5,000
c. Low-Btu Fuel Gas Demonstration Plant	4,000	2,000	12,000	4,500
d. Low-Btu Fuel Gas Small Industrial Demonstration Plants	0	0	0	4,000
e. Direct Combustion Demonstration Plant	0	0	0	6,000
f. Design and Technical Support				
1. Design studies			8,600	6,000
2. Equipment development and critical component testing			12,000	6,000
3. Engineering support			5,900	5,000
4. Environmental and socio-economic studies			1,800	1,400
5. Planning and program support			2,700	3,000
Total Design and Technical Support	5,900	1,750	31,000	21,400
Total Demonstration Plants	27,900	7,750	53,000	40,900
Magnetohydrodynamics				
a. Open-cycle Plasma Systems				
1. Preliminary engineering	9,500	2,075	9,750	10,613
2. Systems design and analysis	1,400	400	4,700	6,070
3. Component and subsystems development (CDIF)	18,679	4,625	16,240	23,913
4. Engineering test facility	1,115	0	0	600
5. Supporting science and technology	1,900	500	3,200	3,870
Total Open-cycle Plasma Systems	32,594	7,600	33,890	45,066
b. Closed Cycle Systems				
1. Inert gas plasma	600	200	800	734
2. Liquid metal	350	0	300	0
Total Closed Cycle Systems	950	200	1,100	734
Total Magnetohydrodynamics	33,544	7,800	34,990	45,800
Total Coal Program	$328,734	$ 83,750	$349,524	$437,500

(Dollars in Thousands)

Summary Table by Technologies: Budget Authority - continued

PETROLEUM AND NATURAL GAS PROGRAM	Actual FY 1976	Actual TQ	Estimate FY 1977	Rev. Est. FY 1978
Enhanced Oil Recovery				
a. Micellar Polymer Flooding	$ 10,400	$ 2,550	$ 7,500	$ 12,500
b. Carbon Dioxide Flooding	2,570	596	5,500	6,600
c. Improved Water Flooding	2,420	300	1,000	3,500
d. Thermal Recovery	6,155	900	4,500	12,000
e. Environmental Studies and Other Support	4,155	300	5,282	11,500
Total Enhanced Oil Recovery	25,700	4,646	23,782	46,100
Enhanced Gas Recovery				
a. Massive Hydraulic Fracturing	6,660	1,450	6,030	11,500
b. Chemical Explosives Fracturing	1,550	500	1,560	1,500
c. Deviated Wells	1,080	150	300	300
d. Resources Characterizations	3,854	900	6,084	7,000
e. Environment and Support	350	100	900	1,700
Total Enhanced Gas Recovery	13,494	3,100	14,874	22,000
Drilling, Exploration and Offshore Technology				
a. Drilling and Exploration	2,090	680	1,800	1,000
b. Environmental and Advanced Concepts Support	139	0	600	600
Total Drilling, Exploration and Offshore Technology	2,229	680	2,400	1,600
Processing and Utilization	1,797	450	1,831	1,400
Total Petroleum and Natural Gas Program	$ 43,220	$ 8,876	$ 42,887	$ 71,100

(Dollars in Thousands)

Summary Table by Technologies: Budget Authority - continued

OIL SHALE AND IN SITU TECHNOLOGY PROGRAM	Actual FY 1976	Actual TQ	Estimate FY 1977	Rev. Est. FY 1978
Oil Shale				
a. Shale Oil Production	$ 9,620	$ 1,300	$ 16,200	$ 21,055
b. Shale Gas Production	3,100	400	3,600	3,850
c. Environmental	1,000	250	1,168	1,380
d. Supporting Research	1,265	300	1,310	1,715
Total Oil Shale	14,985	2,250	22,278	28,000
In Situ Coal Gasification				
a. Linked Vertical Wells/Medium Thick Seams	2,400	625	3,100	4,200
b. Packed Bed/Thick Seams	2,027	700	2,500	2,200
c. Longwall Generator/Thin Seams	800	200	900	1,200
d. Steeply Dipping Bed	0	0	400	1,100
e. Environmental Support	500	50	500	1,200
f. Advanced Concepts and Support Research	410	105	836	1,100
Total In Situ Coal Gasification	6,137	1,680	8,236	11,000
Total Oil Shale and In Situ Technology Program	21,122	3,930	30,514	39,000
Total Fossil Energy Development Operating Expenses	$393,076	$ 96,556	$422,925	$547,600

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Operating Expenses
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT

COAL PROGRAM

PROGRAM STATEMENT

	B/A	Obs.	B/O
Estimate FY 1978	$437,500	$437,500	$384,200
Estimate FY 1977	349,524	464,906	366,424
Increase/Decrease	+$ 87,976	-$ 27,406	+$ 17,776

Coal is the Nation's most plentiful fuel resource with enough reserve to last several centuries. This offers the greatest potential for achieving energy independence in the 1980's and relieve the current U.S. energy shortfall. For example, the U.S. has coal reserves estimated at 3.2 trillion tons of unmined coal, whereas supplies of oil and natural gas are becoming rapidly depleted. Major efforts of the Coal Research, Development and Demonstration program are aimed at tapping this abundant source of energy for direct use as a fuel in an efficient and environmentally acceptable manner or for processing into synthetic fuels needed to do many of the chores previously done by oil and natural gas.

The principal objectives of the Coal Program are to accelerate the development of environmentally acceptable technology for converting coal to liquid and gaseous fuels; to stimulate improved methods for the direct combustion of coal; to foster the rapid development of advanced power conversion systems including magnetohydrodynamics for generating electricity from coal; to validate the technical, economic and environmental acceptability of second generation coal processes, by designing, building and operating near-commercial scale modules; and to expand the technological base and the supply of technically trained manpower to support the evolving coal conversion and utilization technologies.

The budget request for FY 1978 is $437,500,000, an increase of $87,976,000 over the FY 1977 appropriation of $349,524,000. This increase is required to provide for continuation of a balanced and integrated Coal Research, Development and Demonstration Program.

Research and development will continue on coal liquefaction concepts to advance the technology needed for converting coal to low-sulfur, low-ash fuel oil. The products derived from coal liquefaction processes could compete with petroleum refined products in two distinct markets. One market uses low-ash, low-sulfur boiler fuels suitable for clean electric power generation and for industrial steam generation. The other market uses high grade fuels such as gasoline, methanol, diesel oil, heating oil and chemical feedstocks. The development of commercial coal liquefaction processes may provide a route to increased domestic production of clean fossil fuels and feedstocks which complies with all applicable environmental regulations. The FY 1978 request of $107,000,000, an increase of $34,043,000 over FY 1977 will be directed primarily at several pilot plant projects that are underway and to continue other projects including a number of process development units and supporting research and development to enhance coal conversion and utilization technology.

The coal gasification subprograms will include research and development efforts directed toward high-Btu and low-Btu gasification processes. The High-Btu Gasification subprogram includes six major projects for development of an improved process to manufacture

synthetic natural gas. The requested FY 1978 amount for the High-Btu Gasification subprogram is $51,200,000, an increase of $7,146,000 over FY 1977. This will provide for the increased expense of pilot plant operation, the start of a new catalytic gasification pilot plant for producing substitute natural gas, and the development of environmental data needed to support the high-Btu coal gasification effort.

The potential market for clean burning low-Btu gas as a fuel for electric utilities and industrial users, and as a chemical feedstock has increased as a result of the energy crisis, the decrease in natural gas reserves and more stringent environmental regulations. The FY 1978 request for Low-Btu Gasification is $73,900,000, an increase of $40,848,000. This increase is primarily to permit construction of the Combined Cycle Test Facility and a Hydrogen from Coal Facility and to expedite the use of low-Btu gasification systems by industry through the continued funding of projects to be initiated in FY 1977 as a result of a Program Opportunity Notice on Gasifiers in Industry issued in FY 1976.

Research and development will also continue on advanced power conversion systems to establish the technology base for more efficient generation of electricity from coal. The Advanced Power Systems subprogram is aimed toward the development of advanced power conversion systems which will permit, in an environmentally acceptable manner, an increased use of power generation from direct-fired coal as well as the use of coal-derived fuels (e.g., gases and synthetic liquids). The FY 1978 request of $25,500,000, an increase of $3,000,000 over FY 1977, will be used to accelerate efforts on materials and components in connection with the more promising open cycle gas turbine systems. However, closed cycle system development will be maintained at minimal levels.

Efforts will continue under the Direct Combustion subprogram to develop boiler systems capable of burning higher sulfur coals of varying quality in an environmentally acceptable manner, achieve higher combustion efficiency, minimize harmful emissions, and foster adoption of improved processes by powerplants. The FY 1978 request of $53,200,000, an increase of $1,299,000 over FY 1977, will be devoted primarily to the fabrication of several prototype systems in industrial and institutional fluidized-bed combustion application and to accelerate the demonstration of industrial and utility applications of coal oil slurry as a primary fuel.

The Advanced Research and Supporting Technology subprogram will continue to provide research support for all Fossil Energy programs. Its programs in the ERDA Energy Research Centers, National Laboratories and other Government agencies, private industry and universities develop the basic and applied technology and data upon which present and future fuel conversion and utilization processes depend. Included under this subprogram are program planning and development efforts essential to the formulation of fossil energy plans and policy. The FY 1978 request of $40,000,000, an increase of $2,930,000 over FY 1977, will be used primarily to continue ongoing research on new processes, materials and compounds and on direct utilization of fuels.

The Demonstration Plants subprogram request of $40,900,000 for operating expenses in FY 1978 is a decrease of $12,100,000 from the FY 1977 level, and reflects the completion of concept designs for the High-Btu Synthetic Pipeline Gas Demonstration and the Low-Btu Fuel Gas Demonstration Plant projects. The requested funds will provide for continuation of activities associated with demonstration plant efforts initiated during FY 1976 and FY 1977 and permits the start of conceptual design activities for additional plants. In addition to the amounts provided for operating expenses $75,000,000 is included for obligation in FY 1978 under

the Plant and Capital Equipment appropriation. This amount, which is to be discussed in detail later in the justification, is to provide for the preliminary and final design phases of selected plants, initiate site selection efforts, as well as to start procurement actions for long-lead equipment items.

The Magnetohydrodynamics (MHD) subprogram will continue efforts to demonstrate the generation of electricity from coal utilizing MHD processes. The FY 1978 request of $45,800,000, an increase of $10,810,000 over FY 1977, will be used mainly to accelerate the pace of the component development efforts to match the accelerated effort begun in FY 1976 on the Component Development and Integration Facility. Efforts will continue to resolve critical issues in connection with the feasibility of plasma closed cycle systems.

In addition to the direct Federal funds ERDA anticipates significant cost sharing in many of the program areas. We are continuing the present target for cooperative joint funding of one-third private and two-thirds Federal for pilot plants, and 50-50 sharing for demonstration plants.

SUMMARY OF ESTIMATES BY SUBPROGRAM

Page No.	Subprogram	Actual FY 1976			Actual Transition Quarter			Estimate FY 1977			Revised Estimate FY 1978	
		B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
14	1. Liquefaction	$ 97,884	$100,289	$ 55,822	$26,380	$47,490	$24,843	$ 72,957	$ 81,015	$ 84,983	$107,000	$109,800
25	2. High-Btu Gasification	53,364	45,566	48,850	9,250	12,037	13,680	44,054	53,021	58,704	51,200	42,800
36	3. Low-Btu Gasification.	24,552	29,433	19,031	6,720	3,513	4,940	33,052	56,041	39,952	73,900	47,200
45	4. Adv. Power Systems ..	10,001	10,619	2,737	3,500	2,089	2,723	22,500	23,715	12,800	25,500	23,800
50	5. Direct Combustion ...	46,096	30,109	17,951	13,500	26,213	6,466	51,901	74,346	56,826	53,200	56,900
60	6. Advanced Research and Supporting Technology	35,393	36,055	24,067	8,850	11,240	9,892	37,070	38,727	36,570	40,000	42,000
68	7. Demonstration Plants.	27,900	6,397	10,695	7,750	- 838	5,525	53,000	79,154	50,600	40,900	28,700
72	8. Magnetohydrodynamics.	33,544	26,178	22,028	7,800	10,318	9,628	34,990	58,887	25,989	45,800	33,000
	Total Coal Program.	$328,734	$284,646	$201,181	$83,750	$112,062	$77,697	$349,524	$464,906	$366,424	$437,500	$384,200

JUSTIFICATION OF SUBPROGRAMS

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
1. Liquefaction	BA	$ 72,957	$107,000	+ $ 34,043
	BO	84,983	109,800	+ 24,817

Objectives:

The overall objective of the Liquefaction subprogram is to provide technology which is economically feasible and environmentally satisfactory to convert coal of various kinds into clean liquid fuels to replace petroleum based fuels in a variety of applications. The specific objective of this subprogram is to develop to the pilot plant scale alternative processes to produce a heavy boiler fuel for electric power generation and industrial boilers, and a synthetic crude oil suitable for refining to transportation fuels, fuel oils, and chemicals. Simultaneously with the development of the coal conversion processes, this subprogram will develop the refining technology needed to convert crude synthetic oils into the higher grade products, such as gasoline, heating oil, and fuel oil.

Accomplishments:

Major categories in the coal Liquefaction subprogram include research and development in each of the four methods of converting coal to liquids, namely: (a) direct hydrogenation, (b) solvent extraction, (c) pyrolysis, and (d) indirect liquefaction. The products produced by each process differ and because data are insufficient to make sound economic comparisons at this time, a parallel approach is desirable. Selected process options are being investigated to build a broad technological base from which an efficient combination of processes can be developed. Considerable progress was made in the liquefaction R&D effort during FY 1977.

Studies on direct hydrogenation processes consisted of one bench scale project, three PDU projects, and one large pilot plant project. Significant construction progress was made on the 600 TPD H-Coal pilot plant in Cattletsburg, Kentucky; construction of the Synthoil PDU was completed in late FY 1977; and the PDU for the Zinc Chloride Hydrocracking process is near completion. An existing industry-owned Multi-Stage process PDU was in operation to obtain additional data to determine operational reliability the process.

In the solvent extraction area, operation continued at the 50 TPD Solvent Refined Coal (SRC) pilot plant in Tacoma, Washington and at the 6 TPD SRC plant at Wilsonville, Alabama. During FY 1977 several alternative coals were studied and process modifications were tested including the slurry recycle mode (known as SRC-II) at the Tacoma plant. The Donor Solvent process was studied at the 1 TPD PDU level and in a series of laboratory and engineering studies to prepare for the anticipated scale-up to a pilot plant.

Progress in both the pyrolysis and indirect liquefaction areas involved operations of PDU systems on Clean Coke, Flash Liquefaction, Entrained Bed, and the Methanol to Gasoline projects. Coking of residual materials from liquefaction process to recover additional liquid products was under study in two projects. In the support category, refurbishing of the Cresap Test Facility was completed, and operations started. An increasing effort was pursued in refining and upgrading studies.

Budget Request:

The budget request for FY 1978 of $107,000,000 in budget authority is an increase of $ 34,043,000 from the FY 1977 level. The major areas of increases are for the construction of a Donor Solvent Liquefaction pilot plant and the increased costs of construction for the H-Coal pilot plant. In FY 1978 the first full year of a new operating contract for the Cresap Test Facility will require a significant budget increase.

a. Direct Hydrogenation. Direct hydrogenation processes differ in the reactor design and the type of catalyst used. These processes are similar in catalytically adding hydrogen to coal to liquefy it to oil and to remove the sulfur as gaseous hydrogen sulfide, which is then convertible to sulfur for sale. The FY 1978 request consists of an increase of $8,799,000 principally because of the increased cost of construction of the H-Coal pilot plant and the Synthoil PDU operation. Additional funds are also required to start scale-up planning for the Multi-Stage Liquefaction process. The specific objectives of these efforts are to determine operational reliability of each process and in the case of the pilot plants to define the economic outlook for the process.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(1) Ebullated-bed (H-Coal) Pilot Plant	$ 20,800	$ 26,000	+$ 5,200

The H-Coal process utilizes an ebullated bed of catalyst to hydroliquefy the coal to clean fuel oil and/or a synthetic crude oil at choice. Construction of the 200/600 ton per day pilot plant at Cattletsburg, Kentucky, is expected to be completed in FY 1978, and operation is scheduled to begin late in FY 1978. The increased funding is required to finish construction and begin operation and testing of the plant. Co-funding is being provided by industrial firms including Ashland Oil, Inc., Standard Oil Co. (Indiana), Conoco Coal Development Co., Mobil R&D Co., the Electric Power Research Institute and the Commonwealth of Kentucky in the amount of $36,248,000. The Government's share of the total estimated cost of the project of $178,874,000 is $142,626,000 of which $71,741,000 has been funded through FY 1977.

(2) Fixed-Bed (Synthoil) PDU	$ 7,900	$ 11,000	+$ 3,100

In the fixed-bed hydrogenation, or Synthoil process, pulverized coal is slurried with some of its own product oil and then pumped into the reactor with hydrogen at high velocity to create turbulence. The reactor is filled with immobilized

catalyst pellets. The combined effect of the hydrogen turbulence and catalyst is to liquefy and desulfurize the coal at high yields and high throughput. The 10 TPD PDU which is being constructed at the Pittsburgh Energy Research Center, Bruceton, Pennsylvania, is scheduled for completion in late FY 1977. Increased funding in FY 1978 is required to operate the PDU and to continue the comprehensive test program on the smaller bench scale in support of the scale-up program. Total estimated cost of the Synthoil project is $87,462,000, of which $390,000 was contributed by industry in prior years. Government funding through FY 1977 is $42,072,000.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(3) Zinc Chloride Catalyst PDU	$ 2,400	$ 2,000	- $ 400

This project is designed to produce gasoline rather than fuel oil from coal. Basic tests show that through the use of zinc chloride as a hydrocracking catalyst, the objective can be achieved. This process has been satisfactorily demonstrated at a bench scale. Major problems are the recovery of the catalyst and evaluation of product yields. A 100 pound-per-hour PDU will be assembled in FY 1977. Operation of the process development unit is scheduled for FY 1978. This project is jointly funded by ERDA and the Continental Oil Co. and Shell Oil Co.

(4) Disposable Catalyst PDU	$ 601	$ 500	- $ 101

This process uses very cheap catalysts to avoid the expense of recovery. After a single pass with coal through a hydrogenation reactor to convert the coal to oil, the catalyst is discarded with residual ash. Operations of improved disposable catalyst systems, including improved reactor design or other means of increased catalytic activity, are being sought in FY 1977. These operations will be at the bench scale at the Pittsburgh Energy Research Center. The added funds requested are to continue the study of this technology in FY 1978. It is anticipated that an industrial program can be arranged to scale up this work in the future.

(5) Multi-Stage Liquefaction	$ 0	$ 1,000	+$ 1,000

This process utilizes a number of reactors in series, each using an expanded bed of catalyst, to provide kinetic advantage of plug flow through the system. An improved denitrogenation catalyst and an integrated solvent de-ashing process are being investigated. In FY 1977, a PDU project, which was funded with carryover funds, will be underway using the facilities provided by the Lummus Co. at New Brunswick, New Jersey. Funding is required in FY 1978 to start the planning phase for a suitable facility for the scale-up of this process to the pilot plant scale.

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b. *Solvent Extraction.* In processes of this type, coal is converted to a liquid by noncatalytic dissolution in a recycle solvent. The solvent helps to transfer hydrogen to the fragments of the coal and stabilize the oil fractions as the coal is decomposed in the solvent. The principal differences in the processes under study are the reactor conditions and the extent to which the donor solvent is treated and tailored. The sizable budget increase required in FY 1978 is for the initial major cost of design and long-lead-time equipment procurement for construction of a 250 TPD Donor Solvent process pilot plant.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(1) Solvent Refined Coal (SRC) Pilot Plant Operations	$ 19,635	$ 15,000	- $ 4,635

Operation of the 50 TPD pilot plant at Tacoma, Washington, was continued in FY 1977 to explore the use of slurry recycle (SRC II mode) to produce more extensive hydrogenation and to provide needed test products. The $15,000,000 budget request for FY 1978 provides only for continued operation of the pilot plant. If a decision is made to modify the plant, additional funds will be required for the design of a second stage hydrocracking system for upgrading the plant product to a distillate fuel. Total estimated cost for this SRC pilot plant project, which is fully funded by the Government, is $164,431,000, of which $80,431,000 has been funded through FY 1977. A smaller industry financed 6 TPD pilot plant at Wilsonville, Alabama, will be considered for use as an alternative facility for SRC hydrocracking. This facility has already been operated on a cost-shared basis with EPRI for 2 years as a lower cost approach to carry out some of the process studies that otherwise would have required use of the larger Tacoma facility.

(2) Solvent Refined Coal Utilization	$ 1,120	$ 1,000	-$ 120

In FY 1978 this project will consist primarily of combustion tests with SRC. The feasibility of producing SRC has been demonstrated in the pilot plant so the fuel utilization becomes the most critical concern. Utilization testing, similar in level to that of FY 1977, will be scheduled to complement the results in FY 1978.

(3) Solvent Extraction of Lignite	$ 1,000	$ 0	-$ 1,000

This process, which is similar to the SRC process with specific application to Western lignite materials, was tested through FY 1977 at the PDU scale. If scale-up studies are desired, this could best be accomplished in one of the SRC pilot plants so no additional funding is requested in FY 1978.

(4) CO-Steam Process	$ 500	$ 500	$ 0

The use of synthesis gas to hydrogenate moist subbituminous coal at higher pressures than the SRC process is being tested through FY 1978 at the same level as FY 1977 at Grand Forks Energy Research Center.

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(5) Chemicals from Coal	$ 450	$ 400	- $ 50

In this project the emphasis is on the production of chemical feedstocks from coal liquefaction. In FY 1977 a laboratory study of the feedstock value of liquid products from several processes will be completed. The FY 1978 funding is to continue a study of potential chemical feedstock sources.

(6) Donor Solvent Extraction Pilot Plant	$ 2,000	$ 30,300	+ $ 28,300

A major activity scheduled in FY 1978 is the scale-up effort on the Donor Solvent process under development. This process developed by Exxon with other industrial participation by the Electric Power Research Institute involves production of a distillate syncrude product in the primary liquefaction step by use of a carefully tailored donor solvent. The syncrude product is recovered by distillation to affect solid-liquid separation. Recycle solvent (free of solids) is rehydrogenated in a conventional fixed-bed catalytic reactor. In FY 1977 a PDU and engineering support study will be completed to support pilot plant design. The $28,300,000 increase in FY 1978 for this project is for the design of a 250 TPD pilot plant and for procurement of long-lead items of equipment for construction of the plant, and is based on 50 percent ERDA financing of the planned 250 TPD pilot plant program. Total cost of the project is estimated to be $268,000,000 ($134,000,000 Government; $134,000,000 industry) of which $8,500,000 has been funded by the Government through FY 1977. Location of the pilot plant has not yet been determined.

c. Pyrolysis. These projects involve some form of coal pyrolysis or carbonization which amounts to destructive distillation, yielding a liquid product and a char. The projects are aimed at maximizing liquid yield and utilizing the byproduct char. The advantages of the pyrolysis process lie in economy of relatively lower pressure operations. The budget estimate for this category is decreased from $5,400,000 in FY 1977 to $2,000,000 in FY 1978. Projects to be continued in FY 1978 will emphasize the increased yield of liquid products (Entrained-Bed Pyrolysis), and the recovery of additional liquids from residues destined to be used in hydrogen manufacture (Fluid Coking). No funds are allocated for any future scale-up of processes of this type. Work is limited to the PDU scale.

(1) Clean Metallurgical Coke/Liquids	$ 2,400	$ 0	- $ 2,400

The objective of this project is to enable the use of high-sulfur coals for metallurgical coke production, without pollution, and with a simultaneous production of liquids and gases. The Clean Coke process developed by the U.S. Steel Corporation combines pyrolysis and hydrogenation of coal. Three PDU systems are in continuous operation producing products for testing and generating design data. Demonstration of the process on a PDU scale, including testing of several additional coals, should be completed with funds provided in FY 1977.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(2) Flash Liquefaction	$ 900	$ 500	- $ 400

This process, being developed by Rocketdyne Division of Rockwell International Corporation, uses short reaction times for pyrolysis or hydrocarbonization of coal to favor increased yield of liquid products. High-temperature, short reaction time tests using coal and hydrogen are planned for FY 1977. In these tests, coal will be reacted with hot hydrogen using a rocket injector system at very short reaction times. This system offers the potential of a small reactor with very high feed rates resulting in appreciably lower costs. The short-term tests planned for FY 1977 should determine the feasibility of the process and the FY 1978 funding will provide additional data needed to make a decision regarding further scaleup potential for this process.

(3) Entrained-bed	$ 600	$ 500	- $ 100

One of the major problems in processing caking coal at elevated temperatures for producing liquids and gases is the tendency of coal particles to become sticky and agglomerate. Several techniques have been evaluated for eliminating this tendency; among the most promising is the Occidental Research Corporation process which uses rapidly moving char particles in an entrained state to dilute hot coal particles and prevent agglomeration. In FY 1977 this configuration will be tested at the PDU scale. Funds requested in FY 1978 will be used for further operation of the entrained-bed PDU.

(4) Hydrocarbonization/Residue Carbonization	$ 900	$ 0	- $ 900

The concept of this process is to perform the pyrolysis of coal in the presence of appreciable pressures of hydrogen. During FY 1977, a bench-scale unit will be operated at the Oak Ridge National Laboratory. An additional activity will involve the testing of various coal-derived residual liquids for their amenability to pyrolysis. No FY 1978 funding is allocated to this project as it will be completed in FY 1977.

(5) Fluid Coke	$ 600	$ 1,000	+ $ 400

The treatment of residual, solids-containing liquids produced in various coal liquefaction processes is necessary to their eventual economical operation. This project, initiated in FY 1976 and continued in FY 1977, will study the potential of a commercial petroleum process to convert these liquids to a particulate char and to recover contained distillate liquids. The char will be produced in a form suitable for gasification and production of the hydrogen required for liquefaction processes. The FY 1978 funds will provide for appropriate pilot scale tests in an existing test unit.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
d. Indirect Liquefaction	$ 1,100	$ 0	- $ 1,100

Indirect Liquefaction involves gasification of coal into carbon monoxide and hydrogen (synthesis gas) followed by conversion of this gas mixture to liquid fuels by reaction over appropriate catalysts. This process is in commercial operation in South Africa, but is not currently economically suitable for use in the United States. The liquid products currently yielded by this process contain too large a fraction of oxygenated compounds and heavy waxes. Further review of this process is being undertaken.

In FY 1977 the catalytic conversion of methanol to gasoline was under study in a fluid bed reactor. This work will continue into FY 1978 with FY 1977 funding. Since methanol can be made from coal using commercially available technology, the conversion to gasoline completes one route to gasoline that could be of use in the near term if needed. Additional funds will be required after FY 1978 for the extension of the study of new catalysts for the efficient production of high octane gasoline directly from synthesis gas in the same fluid bed reactor system.

e. Support Studies and Engineering Evaluations. Support projects are necessary to facilitate development of the various liquefaction processes toward commercialization. Components of this supporting program include engineering evaluation and design studies, equipment and component test support, refining studies to convert raw coal-derived liquids into specification fuels, studies on hydrogen generation from liquefaction process residues, environmental studies related to liquefaction processes, and other special support activities. The major elements in FY 1978 consist of (1) the start of extended operations at the Cresap Test Facility, (2) initial funding for the design of a pilot plant scale satellite refining facility, (3) special emphasis on environmental research, and (4) studies on a subscale basis to validate a process design for the Clean Boiler Fuel demonstration project.

(1) Cresap Liquefaction Test Facility	$ 5,000	$ 12,500	+ $ 7,500

The Cresap Test Facility located at Cresap, West Virginia, will evaluate various critical systems such as solid-liquid separators and will determine the reliability of conventional equipment such as valves, pumps, heaters, and exchangers which are all common to most liquefaction processes. An integrated liquefaction process designed to produce boiler fuel will be operated at Cresap to provide realistic test conditions. This facility provides a unique capability and is valuable to all pilot plant liquefaction projects. In FY 1977 refurbishing of the facility will be completed and the initial operations will be carried out as the final stage of the basic contract to reactivate the facility. Funds requested for FY 1978 are mainly to initiate a new operating contract to utilize this unique facility. A total of $41,773,000 has been funded by the Government through FY 1977 and industry has contributed $2,000,000. Total estimated cost of the project is $90,273,000 ($88,273,000 Government; $2,000,000 industry).

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(2) Refining	$ 1,300	$ 1,500	+ $ 200

Bench-scale studies were started in FY 1976 to evaluate processes for converting coal-derived crude oils to specification fuels. Tests will concentrate on methods for using existing refinery technology with necessary adaptations for the production of gasoline and fuel oils. In FY 1977 a competitive procurement is planned for the design, construction, and operation of an experimental facility to demonstrate the upgrading of crude coal-derived oils to marketable quality products. This facility will use existing refinery equipment, if available, augmented as required, to process at least 100 barrels per day of oil to make test quantities of specification fuels. This refining project requires the FY 1978 funds indicated as an essential part of the experimental development of coal liquefaction. Total cost of this project is estimated to be $49,730,000. Cost sharing will be required for contract award, but the amount will depend on negotiations.

(3) Environmental Studies and Other Support	$ 3,751	$ 3,300	+ $ 451

Environmental Studies. This effort is to support generic studies applicable to many or all liquefaction projects and to provide support to new project starts. Such studies will consist of, but are not limited to, environmental assessments, process emissions and effluent characterizations. In this way studies not appropriate or limited to single process programs can be performed on a timely basis.

Technical Evaluation and Engineering Support. Experienced architect engineering firms are funded to conduct preliminary reviews of projects and to help appraise the technical status, commercial feasibility, and economic impact of the various processes. Cost estimates of alternative pilot plants are also evaluated for information on the economic viability of alternative processes. The engineering and commercial process economic studies will expedite selection of the most promising processes to meet the variety of liquid fuel needs of the nation. The funding in FY 1978 is required to support the projects that are underway.

Residue Gasification. In this project the feasibility of generating the hydrogen required in liquefaction processes from residues produced in liquefaction is being investigated. In FY 1977 tests are underway in a program initiated and funded in FY 1976. The FY 1978 funds provide for further tests to include additional residues in the program.

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(4) Clean Boiler Fuel Development	$ 0	$ 0	$ 0

During reviews of the design phase of the Clean Boiler Fuel Demonstration Plant project, it became evident that problems were developing with the process, primarily with the hydrocarbonizer. There was a lack of technical data needed to complete a process design for agglomerating coals. In order to initiate this effort in FY 1977 we will propose to reprogram $10,000,000 from the plant and capital equipment appropriation for the Clean Boiler Fuel Demonstration Plant (Project No. 76-1-a). $8,000,000 will be used through FY 1978 to continue the effort, with the remainder planned for completing this effort in FY 1979. The funds will be used to develop further test bed data in small process development units. The data to be derived through smaller scale experiments will provide the information required before any further major commitment of construction funds for the demonstration plant.

SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Ebullated-Bed (H-Coal) Pilot Plant	Cattletsburg, Ky.					
ERDA Funding						
Operating Expenses		$142,626	$ 50,941	$ 20,800	$ 26,000	$ 44,885
a. Design and construction		89,731	46,120	20,800	22,811	0
b. R&D and operational		52,895	4,821	0	3,189	44,885
Capital Equipment		0	0	0	0	0
Total ERDA Funding		142,626 1/	50,941	20,800	26,000	44,885
Consortium of Industrial Firms Funding 2/		36,248 3/	6,435	11,144	7,535	11,134
Total Project Funding		$178,874	$ 57,376	$ 31,944	$ 33,535	$ 56,019

1/ Based on contract.
2/ Includes Ashland Oil, Inc., Standard Oil Co. (Indiana), Conoco Coal Development Co., Mobil R&D Co., EPRI, and the Commonwealth of Kentucky.
3/ Based on Letters of Intent from aforementioned non-Federal participants.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION - continued

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Fixed-Bed Hydrogenation (Synthoil) PDU	Bruceton, Pa.					
ERDA Funding						
Operating Expenses		$ 87,072	$ 34,172	$ 7,900	$ 11,000	$ 34,000
a. Design and construction		26,983	22,579	3,704	700	0
b. R&D and operational		60,089	11,593	4,196	10,300	34,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		87,072 1/	34,172	7,900	11,000	34,000
Bethlehem Steel Corp. Funding		390 2/	390	0	0	0
Total Project Funding		$ 87,462	$ 34,562	$ 7,900	$ 11,000	$ 34,000
Solvent Refined Coal (SRC) Pilot Plant	Tacoma, Washington					
ERDA Funding						
Operating Expenses		$164,431	$ 63,796	$ 16,635	$ 15,000	$ 69,000
a. Design and construction		32,000	22,000	5,000	0	5,000
b. R&D and operational		132,431	41,796	11,635	15,000	64,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		164,431 3/	63,796	16,635	15,000	69,000
Total Project Funding		$164,431	$ 63,796	$ 16,635	$ 15,000	$ 69,000

1/ Based on contracts and budget projection.
2/ Estimated prior years' contribution by Bethlehem Steel Corp.
3/ Based on contract and budget projection.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION - continued

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Donor Solvent Extraction Pilot Plant	(To be determined)					
ERDA Funding						
Operating Expenses		$134,000	$ 6,500	$ 2,000	$ 30,300	$ 95,200
a. Design and construction		60,700	0	0	24,000	36,700
b. R&D and operational		73,300	6,500	2,000	6,300	58,500
Capital Equipment		0	0	0	0	0
Total ERDA Funding		134,000 1/	6,500	2,000	30,300	95,200
Exxon Research & Engineering Funding		134,000 1/	6,500	2,000	30,300	95,200
Total Project Funding		$268,000	$ 13,000	$ 4,000	$ 60,600	$190,400
Cresap Test Facility	Cresap, W. Va.					
ERDA Funding						
Operating Expenses		88,273	36,773	5,000	12,500	34,000
a. Design and construction		38,465	32,465	0	2,000	4,000
b. R&D and operational		49,808	4,308	5,000	10,500	30,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		88,273 2/	36,773	5,000	12,500	34,000
American Electric Power and Allegheny Power Funding		2,000 3/	2,000	0	0	0
Total Project Funding		$ 90,273	$ 38,773	$ 5,000	$ 12,500	$ 34,000

1/ Based on contractor's proposal.
2/ Based on contract and budget projection.
3/ Actual contributions received.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
2. High-Btu Gasification	BA	$ 44,054	$ 51,200	+ $ 7,146
	BO	58,704	42,800	- 15,904

Objectives:

The objective of the High-Btu Gasification subprogram is the investigation and advancement of technology required for the development of improved second generation processes for the production of high-Btu gas from coal. These new improved processes capable of converting coal to substitute natural gas at greater efficiencies could decrease the cost of the product gas by as much as 20 percent, as compared to that produced by current state-of-the-art processes.

The data generated in all phases of the subprogram will be correlated, evaluated and used in preliminary, conceptual, and commercial process designs for each concept under development. These designs will assist materially in economic and technical comparisons, as well as early commercialization of these second generation coal gasification processes. The overall subprogram goal is to provide the technology for construction of full commercial scale plants in the early 1980's.

Accomplishments

Four high-Btu gasification pilot plants will have been constructed, placed into operation and two of these developmental facilities will have completed the tasks of the associated experimental program by the end of FY 1977. Final reports are currently being prepared that describe the work performed by the HYGAS Pilot Plant in Chicago, Illinois, and the Carbon Dioxide Acceptor Facility in Rapid City, South Dakota. Two other pilot plants--the Synthane Plant in Bruceton, Pennsylvania, and the Bi-Gas Plant in Homer City, Pennsylvania--and the Self-Aggomerating Ash PDU in Columbus, Ohio, will be well into their respective operational programs in FY 1977. In addition to the gasification pilot plants, a major auxiliary process project initiated in FY 1973 has started its operational test phase. This pilot plant constructed to develop further the Steam-Iron process for the production of hydrogen required in the hydrogasification of coal is located at the same site as the HYGAS Pilot Plant in Chicago, Illinois.

In 1971, the American Gas Association (A.G.A.) and the Government joined together in a cooperative effort to establish a viable coal gasification industry by means of a joint accelerated research and development program. An agreement was reached to provide funds, jointly, beginning in 1972 on a basis of two-thirds by Government and one-third by industry. As part of the Joint ERDA/A.G.A. High-Btu Gasification Program, efforts were initiated to develop each of four different, but technically feasible, processes for the conversion of coal to high-Btu gas (i.e., HYGAS, Carbon Dioxide Acceptor, Bi-Gas and Self-Agglomerating Ash to a lesser extent), to develop the Steam-Iron and Liquid Phase Methanation auxiliary processes and to test American coals in a Lurgi gasifier.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

As a result of the Government's efforts in combination with the work being performed in the Joint ERDA/A.G.A. program, five pilot plant efforts representing the further development of five different processes for the gasification of coal and auxiliary process for the generation of hydrogen have been initiated. The HYGAS and Carbon Dioxide Acceptor Pilot Plants are constructed and have been operated over periods of time long enough to demonstrate that each process is technically feasible. The experimental program defined for each of these facilities will be completed in FY 1977.

The construction of two other pilot plants and one PDU for the continued development of the Synthane, Bi-Gas and Self-Agglomerating Ash Gasification processes was completed in FY 1976, and the respective developmental programs were initiated. These experimental programs will continue in FY 1977 and will extend into FY 1978. The construction of the Steam-Iron Pilot Plant on a site adjacent to the HYGAS facility was completed also in FY 1976. The work required to develop this concept as an auxiliary process for the manufacture of hydrogen will continue through FY 1977 and FY 1978.

Fabrication of the skid-mounted Liquid Phase Methanation unit was completed in FY 1976. The test program which includes operation of this methanation facility in conjunction with the HYGAS and CO_2 Acceptor Pilot Plants will be completed in FY 1977. The final evaluation of this process will be completed in FY 1978 as part of the engineering evaluation studies.

The High-Btu Gasification subprogram is proceeding successfully through the pilot plant stage of development. Concurrent with the investigation and the development of process technology, data generated during continued engineering evaluations of pilot plant performance will be used in preliminary conceptual designs for each of the candidate gasification processes. The preliminary conceptual design effort initiated in FY 1975 will carry over into FY 1977 with evaluations of these designs continuing into FY 1978. The data generated are also proving valuable in demonstrating where additional development effort is required to make available to any coal gasification process the materials, equipment and auxiliary processes essential to commercialization. From this work, comparative technical and economic evaluations of candidate processes will be prepared.

Budget Request:

Although the developmental work on two pilot plant programs will be completed prior to FY 1978, the budget request for FY 1978 is $7,146,000 greater than FY 1977. This increase can be attributed to a continuing escalation in costs required to operate the remaining pilot plants, the development of a new gasification concept, Catalytic Gasification, at the pilot plant level, continuation in the development of the Hydrane process, and expansion of work in key support programs.

a. Development of Second Generation Gasification Techniques. The funding for the Development of Second Generation Gasification Techniques category has been increased by $5,840,000 above the FY 1977 level. A.G.A. cost-sharing will be continued for the Bi-Gas and Steam-Iron pilot plant projects, but all other ongoing pilot plant and PDU projects will be considered for joint funding on a case by case basis. The additional funds will be used to support: (1) the increased costs of pilot plant operations resulting from escalation in all operational cost accounts, (2) the start of a new project to develop an advanced technique of coal gasification, and (3) the acceleration in the rate of a gasification process now at the PDU stage of development.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(1) HYGAS Pilot Plant (A.G.A. cost-shared)	$ 2,800	$ 0	- $ 2,800

The HYGAS concept of coal gasification attempts to maximize the yield of methane within the hydrogasifier by operation at high pressures. Construction of the pilot plant located in Chicago, Illinois was completed in 1971. In 1974, a steam-oxygen system for the generation of heat and hydrogen required in the hydrogasification of coal was installed. During FY 1975, the system was tested repeatedly and by the end of the period the gasifier had been operated successfully in long-duration runs with lignite coal feeds. In FY 1976, technical feasibility of the concept was demonstrated and the type of coal being tested was changed to a bituminous coal. During FY 1977, operation of the pilot plant will be continued and the experimental program will be completed. At the conclusion of FY 1977 all data required to establish technical feasibility and process scale-up for lignites, subbituminous and bituminous coals, will be available. No further activity in this project is considered in the funding request for FY 1978.

(2) CO_2 Acceptor Pilot Plant (A.G.A. cost-shared)	$ 2,133	$ 0	- $ 2,133

This process, which uses the exothermic heat of reaction of calcium oxide and carbon dioxide to provide a substantial amount of the necessary heat for the gasification reaction, was developed by Consolidation Coal Company. Construction of the pilot plant was completed in late 1971. After solving a number of operational problems associated with numerous interrelated solids transfer systems and fluidized-beds containing two materials of different densities, a number of completely integrated runs were completed. In FY 1976, technical feasibility of the process was demonstrated with a lignite coal containing low concentrations of sodium. During FY 1977, the pilot plant located in Rapid City, South Dakota will be operated to demonstrate technical feasibility while processing a subbituminous coal, as well as a lignite coal with medium and high concentrations of sodium.

During FY 1975, the construction of a methanation unit next to the gasification facility was completed. This system has been operated successfully in combination with the gasification facility to convert lignite to a substitute natural gas with component compositions better than that anticipated in the design of the facility. The experimental program will be completed in FY 1977 and provide all data required to establish technical feasibility and process scale-up for lignite and subbituminous coals. No further work is anticipated in the development of this concept during FY 1978.

(3) Bi-Gas Pilot Plant (A.G.A. cost-shared)	$ 9,800	$ 11,000	+ $ 1,200

The Bi-Gas pilot is located in Homer City, Pennsylvania. As the only slagging-type gasifier now being developed in the High-Btu Gasification subprogram, this process offers the opportunity to determine those operational parameters that will permit maximum utilization of the carbon in the coal and the minimization of the volume of waste products discharged. The conceptual process developed successfully by Bituminous Coal Research, Incorporated, through the bench-scale stage, has

been demonstrated that by operating at high pressures, one-third of the coal added to the primary reactor vessel can be converted to methane directly as it passes through the reactor. The last stage of the reactor is maintained at temperatures high enough to melt the coal ash prior to discharge, insuring maximum conversion of the carbon in the coal fed to the reactor.

Construction of a fully integrated 5 tons-per-hour pilot plant was completed in FY 1976 with shakedown, start-up and initial operation activities expected to extend through FY 1977. The developmental test program will be in progress through FY 1978. The increase in funding of $1,200,000 for FY 1978 over the funding request for FY 1977 represents the anticipated escalation in costs of operation of this pilot plant. Total ERDA funding to completion of the project is estimated to be $103,000,000 with $62,000,000 funded through FY 1977. Total A.G.A. contribution is estimated at $41,806,000.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(4) Self-Agglomerating Burner PDU	$ 2,227	$ 1,500	- $ 727

The Columbus Laboratory (Columbus, Ohio) of the Battelle Memorial Institute is conducting a project for the development of a 2-stage fluidized-bed process for the gasification of coal. This process applies the self-agglomerating, fluidized-bed technique for burning coal with simultaneous pelletization of the ash formed during combustion and offers two significant advantages. First, the agglomerating action that takes place within the burner serves to collect the ash and allows the gas to be expanded in a turbine for recovery and reuse of the energy. Second, the use of the agglomerated ash spherical particles to supply heat to the gasifier eliminates the need for partial oxidation and, thus, the need for oxygen.

Construction of this PDU was started in FY 1974 and was completed during FY 1976. The plant shakedown, start-up and initial operational activities will be performed during FY 1977. The test program initiated in FY 1977 will be continued into FY 1978. The requested funding level for FY 1978 will be used for the operation of this facility. Total estimated cost of the self-agglomerating burner project is $16,773,000, of which $569,000 was contributed by A.G.A. during the initial stages of the project. A total of $14,704,000 has been funded by the Government through FY 1977.

(5) Synthane Pilot Plant	$ 10,500	$ 14,500	+ $ 4,000

The development of the Synthane process is being accomplished as a project in addition to those of the combined Government/industry gasification program. This gasification process has several advantages. It can process any rank of coal, including highly caking bituminous coal, and the inherent simplicity of the gasifier results in good operability

as well as reliability of operation. About 60 percent of the total methane obtained is formed in the gasifier resulting in a reduction in the quantity of oxygen needed as well as the investment capital required to construct the associated methanation facility.

During FY 1975 the construction of the pilot plant at the Pittsburgh Energy Research Center (Bruceton, Pennsylvania) was completed. The associated plant shakedown and start-up activities were completed in FY 1976. The developmental program will extend through FY 1977 and into FY 1978. An increase in funding level of $4,000,000 above FY 1977 has been requested for FY 1978. These additional funds are required to perform some additional laboratory studies needed to optimize key process parameters and to support the estimated escalation of costs anticipated in the operation of this facility. This project is totally funded by the Government and the total estimated cost is projected to be $89,250,000. A total of $39,750,000 has been funded through FY 1977.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(6) Hydrane PDU	$ 1,800	$ 3,500	+ $ 1,700

This process is a promising coal gasification technique in which almost all the producible methane (95%) is generated in the gasifier by direct hydrogasification of the raw coal. This technique results in a high thermal efficiency and makes the Hydrane process potentially one of the least expensive ways to convert coal to substitute natural gas. Additional development effort is being implemented to define the potential design of a viable, one-stage Hydrane process. Engineering evaluations completed in FY 1976 have indicated undesirable features for the original two-stage concept. It is anticipated that during FY 1977 the preliminary design basis for a one-stage Hydrane process will be established. At that time, a decision will be made concerning the detail design for a 20 ton/day PDU. Construction is planned in FY 1979 and 1980 for the Hydrane PDU.

(7) Steam-Iron Pilot Plant (A.G.A. cost-shared)	$ 4,600	$ 5,700	+ $ 1,100

One of the essential raw materials required in the development of the HYGAS process is the adequate and economic supply of hydrogen. Although several techniques suitable for the production of hydrogen are under investigation, the Steam-Iron process, if suitably developed, appears to offer some potential for the generation of this raw material. Construction of the pilot plant on a site next to the HYGAS facility in Chicago, Illinois was started in FY 1974 and was completed in FY 1976. Shakedown and start-up activities will be initiated in FY 1977 with the test program to follow. This experimental program will be continued in FY 1978. As with other pilot plants, the increase in funding requested for FY 1978 will be

used to support the escalation in costs that are anticipated to occur in the operation of these facilities. The total estimated cost of this project is $41,699,000 ($29,047,000 Government; $12,652,000 A.G.A.). A total of $23,347,000 has been funded by the Government through FY 1977.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(8) Catalytic Gasification	$ 0	$ 3,500	+ $ 3,500

One of the principal responsibilities and continuing objectives of the High-Btu Gasification subprogram is the search for and development of alternate and/or advanced technologies for the conversion of coal into a substitute natural gas. This phase of the program is essential to the continued healthy growth of this emerging industry. One of these new advanced concepts is Catalytic Gasification. This process offers considerable promise when suitably developed as a technique capable of generating synthetic natural gas (SNG) more efficiently and economically. The most significant feature of the process is the use of coal impregnated with an alkali metal catalyst. This treated coal can be converted into SNG within the gasifier reactor or in a single processing step. In present gasification techniques the synthesis gas generated in the gasifier must be further processed in several additional steps prior to its conversion to SNG. The preliminary studies required in the continued rapid development of this concept were started in FY 1976 as a project of the Fossil Energy Research Division. These studies will continue through FY 1977 and may extend into FY 1978. The funds requested in FY 1978 will be used to initiate the pilot plant phase of this project. These activities will include evaluation of technical feasibility and preliminary design. If supported by the research of these two activities, detailed design and ordering of long-lead-time items will be initiated in FY 1978. The total estimated cost of this new plant is undeterminable at this time until options are explored, e.g., availability of existing facilities versus new construction.

1. Support Studies and Engineering Evaluations. As the operational and plant design data being generated in the High-Btu Gasification subprogram become available and are correlated, it is apparent that state-of-the-art technology in numerous associated areas (e.g., processing techniques, materials development, equipment availability and environmental responsibility) does not exist or is not adequate for the demands that will be made during the attempt to commercialize any selected high-Btu gasification process. Although the need has been recognized and these efforts did receive funding of $10,194,000 in FY 1977, the acceleration in the rate of the development of gasification technology and the comparative maturity being achieved in some programs require an expanded effort to ensure the availability of needed data. The increase in requested funding of $1,306,000 for FY 1978 will be used in several key areas to ensure that these data are available on a timely basis.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(1) Engineering Evaluations	$ 1,600	$ 3,000	+ $ 1,400

The High-Btu subprogram contains numerous coal gasification pilot plants and auxiliary systems with a large number of complex processing systems embodying all phases of engineering expertise. Diverse types of engineering talents are required to technically support such a program. Highly qualified engineering firms have been contracted to assist in the conduct of the program. These firms are assisting in gathering the essential data necessary to delineate the advantages and disadvantages of each competing process, and to determine which process and/or combination of component processing steps appear to offer the greatest economic potential when constructed as a commercial facility. The evaluations are also attempting to determine those areas of development required to make available all the technical data, materials, and equipment necessary in the construction of a commercial high-Btu gasification facility. Funding for evaluation of the high-Btu gasification projects co-funded by ERDA and A.G.A. is also cost-shared.

The effort, started in FY 1975 on a preliminary conceptual design of a commercial gasification facility for each of the gasification concepts in the combined program, was completed in FY 1977. This work is providing the framework for continued evaluation of the data being generated in the pilot plant effort as well as a comparison of the respective gasification techniques. This work will be continued in FY 1978 as a means of determining the comparative impact of work underway and as a technique for determining those areas requiring additional study. Engineering evaluations will center on the operational performance record of materials, equipment, sub-processes, and gasification systems. These evaluations will provide essential information needed for effective decisions relating to the continued operation of these facilities and assist in the selection of equipment and materials for use in the demonstration high-Btu gasification plants.

Funds in the amount of $1,400,000 above the FY 1977 level have been requested for FY 1978. These funds will permit the start of design suitable for optimizing in plant processing schemes as necessary to obtain maximum operating efficiency and minimizing environmental impacts. These optimization studies will include evaluation of individual pieces of equipment as well as auxiliary systems and their impact on plant performance.

(2) Equipment, Materials and Process Development	$ 4,557	$ 4,100	- $ 457

Equipment Development. During FY 1976 studies were initiated of pilot plant operational data as well as on the preliminary design efforts underway on conceptual high-Btu gasification plants. The studies are being performed to establish exactly what new equipment is required in order to perform at the capacities and conditions anticipated in commercial facilities. These studies will be continued through FY 1977 and into FY 1978. Design efforts will be initiated on some selected equipment items. Effort will concentrate initially on key problem areas encountered during pilot plant operations (e.g., expansion joints, ceramic-lined transfer lines, ceramic valves, lock hopper valves, fluidized-bed level indicators), and identified through consultation with private experts.

The redirection of this effort to concentrate on key areas of high priority with an increased emphasis on an expanded use of the pilot plants as the most suitable place to perform equipment evaluation will permit this program to proceed on schedule at a reduced funding level.

Materials Development. To specify the materials that can survive the stringent conditions of coal gasification with a high degree of reliability it is necessary to know and understand the behavior of many candidate metals and ceramics under actual use conditions. A construction materials test program has been initiated to subject a wide range of materials to actual conditions of temperature, pressure and gaseous components currently existing or anticipated to exist in each of the pilot plants being developed. The data being generated on the response of these materials to their environment is being collected and used to solve specific problems being encountered in pilot plant operations (e.g., chloride stress corrosion cracking, sulfide metal dusting in recycle heaters, refractory failure).

Process Development. Intensive efforts initiated in FY 1976 to survey the industry for all possible processes that are candidates for auxiliary systems in either coal preparation, gas cleanup, synthesis gas methanation and raw material supply were continued in FY 1977. In FY 1978 processes will be evaluated for potential use in a commercial gasification facility. Pilot plant data will be evaluated to determine the relative merits of some auxiliary processes now being used as they might indicate or demonstrate the need for further investigation or the search for more suitable concepts.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(3) Technology Implementation Support	$ 0	$ 1,000	+ $ 1,000

The second generation high-Btu gasification processes have developed into, and in some cases through, the pilot plant stage of development. In FY 1976, an RFP for High-Btu Pipeline Gas Demonstration Plant Projects under the Demonstration Plants subprogram was distributed and during FY 1977 Phase I work will begin on the selected process and/or processes. This work, as well as efforts in the industrial sector, will be rapidly advancing the state-of-the-art in this area of technology. At the same time, this work will uncover critical areas requiring immediate short-term efforts to generate data essential for process and/or equipment design. The present pilot plant support laboratories will offer the most suitable place to perform their directed studies in a minimum amount of time while generating a maximum amount of data. This supporting effort will be initiated as part of the High-Btu Gasification program to gain the maximum utilization of equipment already available and to ensure participation of operational staffs and managers most experienced in this area of technology. This approach will permit the support of this essential work and at the comparatively low funding level of $1,000,000 requested in FY 1978.

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	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(4) Environmental Studies, Other Support and Special Projects.....	$ 4,037	$ 3,400	-$ 637

Environmental Studies. This effort is to support generic studies applicable to many or all high-Btu gasification projects and to provide support to new start projects. Such studies will consist of, but are not limited to, environmental assessments and process emissions and effluent characterizations.

Exploratory Development Gasification. Exploratory development of both state-of-the-art and advanced (third generation) gasification techniques will be continued in FY 1978. This work, initiated in previous fiscal years, is being performed as applied research. Unique reactor designs for both gasification and methanation are being studied. A number of development projects are underway that include the study of a free-fall gasifier that would combine integral pretreatment, carbonization and gasification; the feasibility of a spouting-bed pretreater that would use product gas to replace steam-oxygen mixtures; and the use of heat pipes to add or remove heat from gasification and/or methanation systems. Also extending into FY 1978 will be studies now determined as necessary to achieve balance between the effort spent in advancing state-of-the-art processes and the development of second generation processes. Included among these studies would be comparative evaluation and feasibility investigations of slagging, fixed-bed gasification systems as well as pressurized entrained-bed processes.

Other Support Projects. The development of any high-Btu gasification process requires the initiation and support of a number of studies relating to auxiliary processes that include, but are not limited to, coal handling, coal pretreatment, gas cleanup, methanation, catalyst deactivation, shift conversion, etc. These studies normally are performed concurrently and are directed towards gathering data considered either essential to pilot plant operation or for preparation of a commercial process design and/or economic evaluation. This effort is ongoing and consists of a number of short-term projects, as well as studies directed at achieving long-range objectives. It is essential that those concurrent studies in progress be continued and, as expected by the maturity of the program, expanded to initiate the additional work required for proper support.

Special Projects. Special Projects include process economic evaluations; interprogram trade-off analysis; new technology development (coal preparation, pretreatment, gas clean-up, coal feeder, ash disposal); process design and analysis for overall process optimization; and process reliability and maintainability.

HIGH-BTU GASIFICATION
SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Bi-Gas Pilot Plant	Homer City, Pa.					
ERDA Funding						
Operating Expenses		$103,000	$ 52,200	$ 9,800	$ 11,000	$ 30,000
a. Design and construction		40,000	35,000	1,000	2,000	2,000
b. R&D and operational		63,000	17,200	8,800	9,000	28,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		103,000 1/	52,200	9,800	11,000	30,000
A.G.A. Funding		41,806 2/	16,406	4,900	5,500	15,000
Total Project Funding		144,806	68,606	14,700	16,500	45,000
Self-Agglomerating Burner PDU	Columbus, Ohio					
ERDA Funding						
Operating Expenses		16,204	12,477	2,227	1,500	0
a. Design and construction		11,000	10,000	1,000	0	0
b. R&D and operational		5,204	2,477	1,227	1,500	0
Capital Equipment		0	0	0	0	0
Total ERDA Funding		16,204 1/	12,477	2,227	1,500	0
A.G.A. Funding		569 3/	569	0	0	0
Total Project Funding		$ 16,773	$ 13,046	$ 2,227	$ 1,500	0

1. Based on contract and estimated operational cost.
2. Based on ERDA/A.G.A. agreement.
3. Based on actual A.G.A. contribution.

SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARED FABRICATION - continued

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Years
Synthane Pilot Plant	Bruceton, Pa.					
ERDA Funding						
Operating Expenses		$ 89,250	$ 29,250	$ 10,500	$ 14,500	$ 35,000
a. Design and construction		22,000	18,000	1,000	2,200	800
b. R&D and operational		67,250	11,250	9,500	12,300	34,200
Capital Equipment		0	0	0	0	0
Total ERDA Funding		89,250 [1/]	29,250	10,500	14,500	35,000
Total Project Funding		$ 89,250	$ 29,250	$ 10,500	$ 14,500	$ 35,000
Steam-Iron Pilot Plant	Chicago, Illinois					
ERDA Funding						
Operating Expenses		29,047	18,747	4,600	5,700	0
a. Design and construction		14,000	12,747	1,253	0	0
b. R&D and operational		15,047	6,000	3,347	5,700	0
Capital Equipment		0	0	0	0	0
Total ERDA Funding		29,047 [2/]	18,747	4,600	5,700	0
A.G.A. Funding		12,652 [3/]	7,502	2,300	2,850	0
Total Project Funding		$ 41,699	$ 26,249	$ 6,900	$ 8,550	0

1. Based on actual design and construction costs with additional capital cost based on conceptual design; operating cost based on actual experience.
2. Based on contract and estimated operational cost for one year. Construction to be completed in FY 1977 with operations in FY 1978. A decision to operate beyond FY 1978 has not been made.
3. Based on ERDA/A.G.A. agreement.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

		Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
3. Low-Btu Gasification	BA	$ 33,052	$ 73,900	+ $ 40,848
	BO	39,952	47,200	+ 7,248

Objectives:

The objectives of the Low-Btu Gasification subprogram are to develop and demonstrate, in cooperation with industry, the technology needed for commercial plants to convert coal to environmentally acceptable gaseous fuels with a heating value of 100 to 500 Btu per cubic foot, to establish the required techniques for using these coal-derived gaseous fuels for chemical feedstocks, industrial fuels and combined cycle systems for electric power generation, and to provide incentives required to promote production and utilization of low-Btu gas by private industry.

Low-Btu gasification is a promising method of using coal as a utility and industrial fuel in an economic and environmentally acceptable manner. The potential market for clean burning low-Btu gas as a fuel, and as a chemical feedstock has increased as a result of the energy crisis, the decrease in natural gas reserves and more stringent environmental regulations. The generation of low-Btu gas from coal requires a less complex plant than that needed for the production of high-Btu gas. As a result, capital and operating costs are lower per unit of energy produced. For the most economical generation of electric power, low-Btu gas can fuel a gas turbine/steam turbine combined power cycle. Low-Btu gas can also be utilized in industrial plants normally dependent on natural gas, oil or coal.

The subprogram provides for the development, in cooperation with industry, of major projects in which low-Btu gasification systems can be directly integrated with industrial and utility uses. Program Opportunity Notices (PON's) for the Gasifiers in Industry, Hydrogen from Coal plant, and the Combined Cycle Test Facility projects are representative of these efforts. Proposals for these projects are to be evaluated in FY 1977, with subsequent initiation of design and construction. During FY 1978, these projects will be carried through the construction phase toward operational status.

Continued efforts will be made to develop new gasifier technology, gas purification systems, and process components for use in pilot plant and commercial facilities. These new technologies will have the benefits of feedback information from operating industrial systems. As these new developments mature, pilot facilities will be tested in the combined cycle facility and industrial end-use applications.

Accomplishments:

Significant progress has been made in development of new gasification systems. The atmospheric pressure, entrained-bed PDU is in the construction phase with operational start-up planned for late FY 1977. Successful, continuous operation has been

achieved in the volatilization section of the two-stage fluidized-bed PDU. The molten salt gasification plant is currently in its final design stage at its new site in California. This plant was relocated from Connecticut to take advantage of better supporting facilities at the new site. Design data and a full plant definition are nearing completion for the pressurized, entrained-bed pilot plant. PON's were released for the Gasifiers in Industry and the Hydrogen from Coal plant. Proposals received in response to the Gasifiers in Industry PON have been evaluated and multiple awards are anticipated in FY 1977 covering a variety of industrial and institutional uses for low-Btu gas from coal. Proposals received as a result of the Hydrogen from Coal facility PON are being evaluated and a contract for conceptual design of a facility is expected to be awarded in FY 1977.

Construction will be initiated in FY 1977 for the Powerton combined cycle test facility at Pekin, Illinois. This project will permit evaluation of various sytems, subsystems and components of a coal gasification combined cycle pilot plant for electrical power generation.

Budget Request:

The budget request for funds to support the activities of the Low-Btu Gasification subprogram in FY 1978 is $40,848,000 above the FY 1977 level. This increase in funding responds to industry's greater need and higher priority for an alternative source of energy to replace that being lost through reallocation of natural gas plus the increased cost of oil. Specifically the FY 1978 program will emphasize increased program activities in fluid-bed gasification as major decisions will be made concerning the two-stage, three-stage and fast-fluid systems. In addition, the Gasifiers in Industry program will be very active in FY 1978 with start-up of some systems expected.

At the same time the construction of the Hydrogen from Coal Facility will be proceeding at a fast pace with completion scheduled for FY 1979. Finally, hot gas cleanup efforts will be accelerated to respond to the increased need created by the Combined Cycle Test Facility.

a. Gasification Processes. The efforts in the Low-Btu Gasification Subprogram are responsive to the growing demand for development of processes that can generate an alternate source of fuel gas to satisfy the needs of industry and power generation. The costs of accomplishing the objectives for development of gasification processes reflect the acceleration of this effort. These additional funds are required to support the development of two major new facilities (the Hydrogen from Coal plant and the Combined Cycle Test Facility) and provide for the modification and continued operation of a number of other test units. Funding at this higher level will permit the continuation of a closely integrated development program directed towards providing near term solution to the supply of a fuel gas as well as providing the foundation for longer term development programs that will result in the availability of coal as a source for hydrogen as well as fuel gas more efficiently generated in greater volume with less intensive capital requirements.

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(1) Fixed-bed Gasification, Atmospheric	$ 2,950	$ 4,550	+ $ 1,600

The Low-Btu Gasification Subprogram has two projects underway that are directed toward advancing the technology of fixed-bed gasifiers and expanding their suitability for the generation of fuel gases.

In the first project, minor modifications to the existing, stirred, fixed-bed gasifier at the Energy Research Center in Morgantown, West Virginia, have been completed. These include improved methods for coal feeding, ash removal, stirring, lock hoppers, and data collection. A scrubber and a hydrogen sulfide removal system will be provided to clean up the product gas for use in combustion and turbine blade corrosion tests. Requests for Proposals will be released for the design of a full flow product gas scrubber and hydrogen sulfide removal system. In addition, a complete water purification system will be installed. Construction is to begin on these subsystems in FY 1977. Operation of the fully integrated process, including gasifier, cleanup, and combustion will begin in late FY 1978.

The second project is a continuation of effort initiated in FY 1975 at Grand Forks Energy Research Center, North Dakota, to continue development of a slagging, fixed-bed gasifier. In the current phase of the project, the gasifier is being operated to investigate the characteristics of effluents as well as determine the comparative amounts being produced. In addition, the suitability of various Western coals for gasification by this process will be determined. The 25 tons-per-day gasifier constructed earlier has been reactivated for this work. Previous results were very favorable in terms of capacity and steam requirements. Preliminary test runs are in progress and the planned operational program initiated in FY 1977 will be continued in FY 1978.

Funds in the amount of $1,600,000 above the FY 1977 level are required to complete the described modifications of the stirred fixed-bed gasifiers and to support the experimental programs at an increased level of activity.

(2) Fluid-bed Gasification, Pressurized	$ 1,700	$ 5,000	+ $ 3,300

The technique of pressurized fluidized-bed gasification developed by Bituminous Coal Research, Inc., Monroeville, Pennsylvania, will make available coal gasification processes particularly suited to the generation of a low-Btu fuel gas. Three ongoing projects will be continued in FY 1978.

The first system utilizes a three-stage gasifier. A one ton-per-day process development unit (PDU) was completed in FY 1976 and the associated test program started. These studies were continued in FY 1977 and will be extended through FY 1978 to generate data needed for determining technical and economic feasibility as well as to provide a basis for scale-up in size. During FY 1978, some additional equipment will be installed to permit continuous operation and evaluation of more process variables.

The second project will focus on the development of a two-stage pressurized fluidized-bed gasifier which can use caking coals without pretreatment. A PDU with coal feed design capacity of 1,200 pounds per hour has been constructed and the numerous auxiliary subsystems are being evaluated at the Westinghouse laboratory in Waltz Mill, Pennsylvania. Operation of the first fluid-bed stage has shown that the unit can devolatilize caking coals without pretreatment. The second stage will be tested during FY 1977. Integration of the two stages will be completed and integrated operation will be initiated in FY 1977 and continued through FY 1978. A demonstration of completely integrated PDU operation with a subsequent detailed analysis of the operational test data is scheduled for the end of FY 1978. At that time a decision will be made on the need for further development of this concept in a larger facility.

The third gasifier under study utilizes a processing technique with the descriptive title of fast fluidized-bed operation. The objective of this project which is being developed by Hydrocarbon Research, Inc., Trenton, New Jersey, is to build and operate a test facility to evaluate the feasibility of this concept. The work was initiated during the Transition Quarter with the first phase scheduled for 33 months or through FY 1978. The technical status review scheduled to be performed at the end of this first phase will determine whether the potential advantages of the gasifier (e.g., higher capacity by several orders of magnitude, no tar formation, higher turn-down capability, and use of all types of coal) can be obtained.

FY 1978 funding must be increased over FY 1977 to support the simultaneous operation of these experimental and interrelated facilities. In this manner more conclusive results will be produced in a shorter period of time.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(3) Entrained-bed Gasification Pilot Plant	$ 500	$ 0	- $ 500

This project is now underway as a three-phase project consisting of design, construction and operation of a five-ton per-hour pilot plant at Windsor, Connecticut. Under Phase I of the project, now nearing completion, the facility was designed and evaluated to determine technical and economic feasibility of the process. Phase II, the pilot plant construction, has been started and is scheduled for completion in FY 1977 at which time the operational test program will be initiated. The successful completion of the program will result in the development of a gasifier that can be operated at a heat rate (10,200 Btu/KWhr) approaching that of a conventional coal-fired generating plant. This potential makes this gasifier one of the more promising for early utility use.

The project is proceeding as a co-funded effort in which the Government is providing two-thirds with Combustion Engineering, Inc., and EPRI providing one-third of the cost. Although the work was totally funded in FY 1975, funds were received in FY 1977 to support the additional cost of this project. Those funds should be sufficient to complete the program therefore, no additional funds are requested as part of the FY 1978 budget.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(4) Combined Cycle Test Facility ("Powerton")	$16,500	$28,000	+ $ 11,500

A major problem in the adaptation of low-Btu gasification processes to use in combined-cycle power plants is the combination of the gasification and gas purification units with gas turbine electrical generating units. During FY 1977, the construction of a pilot plant to explore this problem will be initiated. The pilot plant will process 500 to 800 tons of coal per day; convert the coal to a purified low-Btu gas; and utilize the gas to drive a combustion turbine for electric power generation. Areas will be provided for integration of future, improved gasification and purification units, and second generation, higher-temperature combustion turbine. Load-following characteristics of the various components will be evaluated. Cost-sharing commitments for the project of about two-thirds Government and one-third provided by Commonwealth Edison, EPRI and the State of Illinois are anticipated. Total project cost is estimated at $167,000,000 ($116,000,000 Government funding; $51,000,000 industry contribution).

The construction of the "Powerton" facility started in FY 1977 at Pekin, Illinois and will be continued into FY 1978. The primary purpose of this facility is the integration of gasification and purification systems with the combined cycle power generation system. It is anticipated that shakedown operations will require the use of several alternative control systems to establish an optimum configuration. The increased funds will cover anticipated construction costs for these alternative systems.

(5) Molten Salt, Pressurized, PDU	$ 1,000	$ 0	- $ 1,000

In this process, which is being developed by Atomics International, Santa Suzanna, California, coal is partially burned and completely gasified in a bath of molten salt. High sulfur, caking coal can be gasified with the sulfur and ash being retained in the melt. The low-Btu gas produced contains some salt particles which are removed before the gas is used for electric utility industry support. Design of the pressurized PDU was begun in FY 1976 and construction will start in FY 1977.

The funds necessary to support the development of this concept were provided in earlier budget requests up to and through the request made in FY 1977 for $1,000,000. Accordingly, additional funds are not being requested as part of the FY 1978 program for this project.

(6) Hydrogen from Coal Facility	$ 5,000	$18,000	+ $ 13,000

Hydrogen is an essential raw material needed in coal conversion processes as well as in many industrial processes. This project was initiated in recognition of a critical need for alternate sources of this raw material in other phases of coal gasification and liquefaction as well as for industries that now consume natural gas to generate hydrogen.

A Program Opportunity Notice (PON) was issued in FY 1976 that called for industrial co-funding on an equal basis with the Government. Proposals received as a result of this PON for the conceptual design of a hydrogen-from-coal facility are being evaluated and a contract is expected to be awarded in FY 1977. It is anticipated that the hydrogen generated from this facility will be used in an industrial process. The funding of the effort described in the PON will provide for the design and construction of the facility as well as for its operation for up to three years. These design and construction activities will be continued through FY 1978. During operation, the facility will consume, as a minimum feed rate, 200 tons of coal per day to produce approximately 30 tons-per-day of hydrogen. The project has an industry cost sharing target of 50-50. The Government's share of the total estimated cost of the project is $87,000,000. A site has not yet been selected.

The additional funding requested in FY 1978 above the FY 1977 level is required to support the construction of the facility. This construction activity will be in progress throughout FY 1978. A major portion of the construction costs will be incurred during this period.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(7) Ash Agglomeration	$ 0	$ 1,300	+ $ 1,300

Previous operation of an atmospheric fluidized-bed gasifier on char and fine coke particles has demonstrated that gasification under ash agglomerating conditions is possible. The existing gasifier is being modified to allow operation on coal as feed with operation scheduled for FY 1977 and FY 1978. Based on operational data, it is planned to increase scale of operation and perform tests at elevated pressure. This project was initiated in FY 1976 and will be continued through FY 1978. The funds allocated to the program at the start were sufficient for facility modification and initial operation. The funds requested in FY 1978 will support the continued operation of the gasifier to achieve all objectives of the program.

b. Support Studies and Engineering Evaluations. Concurrent with increased level of activity in the development of gasifier systems and in response to the increased size and complexity of some gasifier projects, it is necessary to provide additional program support and to initiate those engineering studies necessary to evaluate these systems. The increased funding level for FY 1978 of $6,648,000 above the level for FY 1977 is required to accelerate the rate of development of auxiliary systems and initiate work in key areas of equipment assessment and materials evaluation.

(1) Hot Gas Cleanup	$ 2,600	$ 3,600	+ $ 1,000

Cleanup with Molten Salt. The molten salt gas cleanup system offers potential for removing both particulates and sulfur contaminants from low-Btu gas at elevated temperatures. This is achieved by using molten salts as a medium for scrubbing the gas. The primary constraints on the success of this process is the development of a continuous method of removing the impurities collected by the molten salt.

A PDU which has been operated on a batch basis at the Battelle Pacific Northwest Laboratories, Richland, Washington, to remove contaminants by use of molten salt will be converted to continuous operation by early FY 1977. Continuous operation for periods up to 8 weeks in length is anticipated during FY 1977. The PDU results will provide data for cost analysis and design of a pilot plant facility. A decision point will be reached by the end of FY 1977. A favorable decision would initiate design and possible construction effort during FY 1978. The objective will be to provide a unit suitable for integration into the Combined Cycle Test Facility.

Cleanup with Iron Oxide. Solid absorbents for sulfur compounds have been developed and tested on a laboratory scale. A variety of absorbents are being developed with greater sulfur removal capacity, longer life at both operation and regeneration cycles, greater strength and improved stability at elevated temperatures. Optimum design parameters are being selected and a tentative dynamic model of the absorption system is being developed. This model will assist in extrapolating bench-scale and PDU data to pilot plant and commercial systems. A bench-scale system will be operated during FY 1977. The possible use of a fluidized-bed system will also be investigated during FY 1977. In late FY 1977, a decision will be made leading to the design and construction of a PDU to evaluate the preferred system. The PDU will be operated in conjunction with the Morgantown Energy Research Center gasifier.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
(2) Gasifiers in Industry	$ 1,000	$ 10,000	+ $ 9,000

This project is a critical support activity for the development of meaningful and usable components for gasification systems. Its aim is to determine, utilizing state-of-the-art components, the integration of a gasification system with an industrial end-use for the low-Btu gas produced. Since low-Btu gas must be utilized at its point of production because of prohibitive cost of transporting, factors controlling the connection of the gasification to an end-user of the gas must be evaluated. These factors would determine acceptability of future, advanced gasification techniques.

Small sized individual gasifiers are currently available and will be the first application and use of synthetic fuel conversion from coal on the market. The Government involvement in this area is of short duration and focuses on the use of these gasifiers for caking coals and evaluating environmental safety. These projects will be heavily cost shared by industry.

A recently issued Program Opportunity Notice (PON) calls for proposals to achieve the following objectives:

(a) Demonstrate low-Btu gasification technology by integrating and evaluating coal gasification systems in some varied operating environments.

(b) Accumulate and analyze technical data on component and system operating parameters which will assist in the design and development of advanced state-of-the-art prototype coal gasification systems.

(c) Decrease the consumption of natural gas and fuel oil in the near term through application of state-of-the-art systems until advanced, second generation coal gasification systems are available.

Proposals received in response to the PON have been evaluated and multiple awards are anticipated in FY 1977. Actual construction of the facilities is expected to occur during FY 1977 and FY 1978. The initial activities leading to the start of construction of these facilities will be supported by funds received in FY 1977. The increased funding level of $10,000,000 will be required to complete the construction of these test units. The operation of these systems will begin in FY 1978 and continue for several years.

		Budget Authority		
		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(3)	Environmental Studies, Other Support and Special Projects	$ 1,802	$ 3,450	+ $ 1,648

Environmental Studies. This effort is to support generic studies applicable to many or all low-Btu projects and to provide support to new-start projects. Such studies will consist of, but are not limited to, environmental assessments, process emissions, and effluent characteristics.

Engineering Support. Technical and engineering services, including assistance in process evaluation, process selection, preparation of cost estimates, mathematical modeling of gasification processes, preliminary engineering design, and engineering evaluation are required as an essential component of the Low-Btu Gasification subprogram. These activities provide data essential to proper management.

Compilation of the coal conversion data book will be continued in FY 1978. This handbook will be a comprehensive source of data on coal conversion systems, and will be valuable to the entire fossil energy program. It will provide information on which to base the design and operation of coal conversion systems.

Materials and Equipment. The development of gasifiers and auxiliary systems for the generation of a fuel gas must have associated with it a program directed specifically to solving the unique processing requirements imposed upon the equipment and their materials of construction. It is essential to, prior to the expenditure of large sums of money for complex equipment, know and understand the behavior of many candidate metals and ceramics under actual use conditions. The data then generated in those programs supported by the requested funds is essential to solving those specific problems that will be encountered in pilot plant operation.

Other Support. Consistent with the continued review of the overall program objectives as well as redefinition of program tasks, some support projects have been changed in format and/or phased out as the requirement for the data has been satisfied. This continuing activity is necessary to assure that funding resources are directed into research and development channels which offer the greatest potential for near and long-range solutions to energy problems.

Special Projects. Special projects include process economic evaluations; interprogram trade-off analysis; new technology development (coal preparation, pretreatment, gas cleanup, coal feeder, ash disposal); process design and analysis for overall process optimization; and process reliability and maintainability.

LOW-BTU GASIFICATION
SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Combined Cycle Test Facility	Pekin, Illinois					
ERDA Funding						
Operating Expenses		$116,000	$ 14,550	$ 16,500	$ 28,000	$ 56,950
a. Design and construction		64,550	14,550	16,500	28,000	5,500
b. R&D and operational		51,450	0	0	0	51,450
Capital Equipment		0	0	0	0	0
Total ERDA Funding		116,000 1/	14,550	16,500	28,000	56,950
Non-Federal Organization Funding 2/		51,000 3/	0	25,000	10,000	16,000
Total Project Funding		$167,000	$ 14,550	$ 41,500	$ 38,000	$ 72,950
Hydrogen from Coal Facility	To be determined					
ERDA Funding						
Operating Expenses		87,000	0	5,000	18,000	64,000
a. Design and construction		47,000	0	0	17,000	30,000
b. R&D and operational		40,000	0	5,000	1,000	34,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		87,000 4/	0	5,000	18,000	64,000
Non-Federal Organization Funding 5/		87,000 6/	0	2,500	18,000	66,500
Total Project Funding		$174,000	$ 0	$ 7,500	$ 36,000	$130,500

1/ Based on Fluor Engineering detailed cost estimate prepared for contractor.
2/ Includes Commonwealth Edison, EPRI, and State of Illinois.
3/ Based on commitment from aforementioned organizations.
4/ Based on ERDA estimate.
5/ To be determined.
6/ Provision of Program Opportunity Notice procurement.

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
4. Advanced Power Systems	BA	$ 22,500	$ 25,500	+ $ 3,000
	BO	12,800	23,800	+ 11,000

Objectives:

The objective of the Advanced Power Systems subprogram is to develop advanced power generation systems to the technology readiness stage in preparation for engineering into prototype electric power generation systems. The systems under development have been selected on the basis of evaluations which showed the likelihood of electric power generation at lower cost and attractive efficiency when compared with current technology. The systems are all based on technology using coal containing appreciable sulfur content, or partially clean coal-derived gaseous or liquid fuels, in an environmentally acceptable manner.

The major potential economic advantages offered by these advanced power systems result from the fact that high performance combined cycle turbine systems could have lower capital cost and are expected to offer an attractive coal to electrical power generation efficiency.

Additional benefits from the use of advanced power generation systems include:

Reduced water requirements enabling electric power to be generated in arid areas of the U. S., where coal is abundant;

Reduced fuel requirements of potentially high-efficiency generation equipment;

The creation of technology which can also be used with existing premium synthetic and natural liquid and gaseous fuels at higher efficiency.

The budget categories included under the Advanced Power Systems subprogram are Open Cycle Gas Turbines, Closed Power Systems and Support and Additional Projects.

The open cycle gas turbines developed in the United States were predominantly for military and civilian jet aircraft. The United States has also developed heavy duty, long life, open cycle gas turbines for the utility and industrial markets. Both aircraft and utility gas turbines have been designed to burn clean fuels exclusively; however, recent development work is expected to enable ship propulsion gas turbines to burn lower grade fuels.

A turbine system with a high turbine inlet temperature (over 2500°F) burning coal derived fuels, utilizing materials, internal cooling and component designs specifically for high reliability utility service, rejecting heat to a heat recovery boiler which generates additional steam turbine power, appears highly attractive. This system concept offers potentially lower capital cost, shortened construction time and higher efficiency than a conventional high pressure steam powerplant. This system is typically referred to as a combined cycle plant.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

The closed cycle power systems have been categorized into two main areas, the Closed Cycle Gas Turbine (CCGT) system and the Alkali Metal Vapor Turbine (AMVT) system. The Closed Cycle Gas Turbine system has primarily been developed in Europe since 1939. At least 15 of these European systems have operated industrially; the original system (2 MWe) has operated over 120,000 hours and the largest system (50 MWe) has been commissioned this year. These projects have used air, gas mixtures, and helium as working fluids and have operated with turbine inlet temperatures as high as 1380°F. They have burned coal, among other fuels, in the heaters. In the United States, small closed cycle gas turbine systems have been used by the Department of Defense for land-based power and by the National Aeronautics and Space Administration for space applications. American industry is just beginning to become interested in exploring closed cycle systems for utility and industrial service. Alkali metal vapor turbine systems have been built and tested in small power sizes. Major development tasks include large size boiler and condenser engineering, long life materials qualification, and full size turbine engineering.

Accomplishments:

Open cycle gas turbine projects initiated in FY 1976 were continued in FY 1977 to utilize coal derived fuels in an environmentally acceptable manner in gas turbines operating as the topping portion of combined cycles. Specifically, these projects started with system definition studies to determine both technical and economic factors of promising gas turbine system designs. Gas turbines show increases in both power output and efficiency when turbine inlet temperatures are raised with modest requirements of cooling fluids; consequently R&D efforts initiated in FY 1976 in blade and vane cooling, ceramic component evaluation, and materials corrosions and reliability studies were continued. The combustion of partially cleaned coal derived fuel produces solid particulates which are damaging to gas turbine blades. Projects started in FY 1976 continued to evaluate improved blade durability as well as the cleanup of particulate matter reaching the gas turbine and coal derived fuel cleanup methods to improve turbine life and reliability.

In the closed cycle power systems area, two approaches are presently being pursued. The first is the Closed Cycle Gas Turbine which would operate with the direct combustion of coal in a primary heat exchanger. Second, is the Alakli Metal Vapor Turbine which shares the potential for improved system efficiency and the possibility of improved power generating costs. In both closed-power systems, work has proceeded on the high temperature heater or boiler, on materials evaluation and on system studies to evaluate overall power generating costs. The work on the boiler technology for the alkali metal vapor topping turbine system is being performed at the Oak Ridge National Laboratory. Shakedown tests on the alakli metal vapor boiler using water will be completed in FY 1977.

Program management support and technical evaluations of advanced concepts and new systems are also a necessary component of this subprogram. FY 1977 efforts include advanced power cycle studies, rotors, seals and instrumentation control assessments, support from NASA in critical areas and MIT support for advanced technology. These efforts provide a mechanism for initiating new projects in the field of improved coal utilization as new techniques and processes become known and reach appropriate stages of economic justification. The results may be incorporated in either the open cycle or the closed system projects. Also, initial investigations are conducted of new technology, and improved reliability of present generation plants which can use coal-derived fuel, and special projects, and environmental studies.

Budget Request:

The FY 1978 budget request of $25,500,000, in budget authority, is an increase of $3,000,000 over the previous fiscal year. The total increase includes $2,300,000 for efforts associated with Phases I and II of the Open Cycle Gas Turbine category, such as improved cooling, blade and vane research, bearings and seals selection, and combustor development and is required to support necessary component testing in FY 1978. Expanded experimental efforts on the Closed Cycle Power Systems will be required in order that necessary subsystems and components will be available for use as prototype turbines in the early 1980's, requiring an increase of $620,000 for this category.

Efforts in the area of Support and Additional Projects will also be increased by $80,000 over the FY 1977 level. The increase will be concentrated on the development of high temperature components, and the development of the improved materials and systems that would improve the performance and reliability of high-temperature, high-performance turbine utility power systems.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Open Cycle Gas Turbine	$ 16,400	$ 18,700	+ $ 2,300

Contracts with four major turbo-machinery manufacturers were signed in FY 1976 for Phase I which provides systems definition of the technology readiness program. Phase II of this major program, which will be underway in FY 1977 with at least two of these contractors, includes design of test equipment and components for testing, then fabrication of the test equipment and the beginning of technology readiness verification. FY 1978 funds must provide for procurement of long lead items for Phase III, which will permit completion of verification testing. The majority of the funding in the Advanced Power Systems subprogram is in the Open Cycle Gas Turbine development projects. The turbines being developed under the program are for use with coal generated low-Btu gas turbine-steam turbine combined cycle plants. Cost and performance studies by contractors, NASA and EPRI have shown that such systems are among the least espensive and most efficient systems which can reach the levels of technical maturity in the next fifteen years. A very preliminary total estimated cost for Open Cycle Gas Turbine Development is $307,000,000, which includes both high and low temperature turbine technology.

b. Closed Power Systems.

Phase I of the closed cycle primary heater was begun with contracts with at least two major industries to conduct the system definition efforts of the project which include system analysis, multiple conceptual designs, preliminary detailed heat exchanger designs, program plan and establishment of a reference power system design. Phase II, which will commence in FY 1978, will require procurement of test equipment modules. The alkali metal vapor boiler water shakedown tests will be completed in FY 1977. Also the system definition will be completed in FY 1977. Additional funds are required in FY 1978 for conversion to potassium or cesium testing in the boiler. Detailed design and analysis will be initiated in FY 1978 with industry.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

The closed cycle systems presently do not appear as attractive as the open cycle systems and are receiving funding on an appropriately lower level. The work on these systems will concentrate on systems configuration optimization and technology work on key components so that data will be generated which can be used to either develop key components or discontinue work on the systems.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(1) Closed Cycle Gas Turbine/Primary Heat Exchanger	$ 1,500	$ 3,250	+ $ 1,750

Phase I (1977) will consist of the following tasks:

1. Working fluid and cycle analysis studies;
2. Interface design criteria selection and establishment of reference power conversion system design;
3. Consolidate primary heat exchanger conceptual designs;
4. Primary heat exchanger detailed preliminary designs;
5. Key features analysis of the primary heat exchanger detailed primary designs;
6. Plan identifying specific research and development necessary to eliminate the problem areas.

Phase II (1978). The facilities and equipment will be procured for testing of the critical components of the heat exchanger. Test components will be designed and procurement initiated. Long-lead items shall be procured. Test plans and procedures are to be initiated so that they are established by FY 1979.

(2) Alkali Metal Vapor Systems	$ 1,380	$ 250	- $ 1,130

FY 1977 - completion of testing with water to shakedown test the alkali metal vapor boiler. On completion of testing of the boiler with water, the boiler will be converted so that it can be set up for the extensive tests with potassium or cesium.

FY 1978 - complete conversion of boiler for tests with alkali metal vapor and then perform the initial testing. A design for a fluidized-bed driven alkali metal vapor system will be defined in FY 1977 in sufficient detail to analyze its key problem areas. In FY 1978, one or more contracts (competitive) will be awarded with industry to conduct detailed design and analysis of the key components of the fluidized-bed heat exchanger. Such design and cost information will be used to determine whether the increased efficiency achievable with alkali metal vapor systems is sufficient to justify their added cost. Program continuation in future years depends on whether or not a system can be developed which utilities would use.

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(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

	Budget Authority Estimate FY 1977	Estimate FY 1978	Increase or Decrease
c. Support and Additional Projects	$ 3,220	$ 3,300	+ $ 80

Supporting and additional programs were initiated in FY 1976 and expanded in FY 1977 which included the Energy Conversion Alternatives Study (ECAS), assessment of ceramics, fireside corrosion, and reports on up-to-date European activities in advanced power conversion technology. The FY 1978 request also provides for additional efforts in fireside corrosion, NASA support, special projects, environmental studies, combustion studies, reliability studies, plant integration efforts, hot gas cleanup and heat transfer studies.

(1) Support Studies. Support studies shall include advanced power system studies, programmatic support in plans and programs, heat transfer, rotors-bearings-seals, instrumentation and controls, NASA efforts in critical research areas, reports on other associated technologies, and some specialized consulting and evaluation.

(2) Additional Programs. Additional programs shall include fireside corrosion, hot gas cleanup, coal burning diesel engine power systems, research technologies, combustion efforts, reliability programs, and plant integration plans.

(3) Environmental Studies. Environmental studies is a newly defined effort to support generic studies applicable to many or all Advanced Power Systems projects. Such studies will consist of but are not limited to environmental assessments and process emissions and effluent characterizations.

(4) Special Projects. Special projects include process economic evaluations; interprogram trade off analysis; new technology development (coal hot separation, pretreatment, gas cleanup, coal feeder, ash disposal); process design and analysis for overall process optimization; and process reliability and maintainability.

		Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
5. Direct Combustion	B/A	$ 51,901	$ 53,200	+ $ 1,299
	B/O	56,826	56,900	+ 74

Objectives:

The primary purposes of this subprogram are: (1) to develop both atmospheric and pressurized systems capable of burning high-sulfur coals of all degrees of rank and quality directly in fluidized-bed combustors in an environmentally acceptable manner; (2) to develop technology to substitute coal for a substantial portion of oil in existing oil-fired combustors capable of firing coal-oil mixtures; and (3) to improve the reliability and efficiency of present boilers. The strategy for combustion research is directed toward:

a. Developing a new mode of clean and economic coal combustion for powerplants, industrial and institutional users having the potential for substantial improvements over conventional coal-firing modes;

b. Determining methods to burn synthetic, low-sulfur fuels derived from coal, and the chars from coal conversion processes;

c. Minimizing or preventing fouling and corrosion of heat transfer surfaces in coal-fired boilers.

Implementation of fluidized-bed boilers and heaters is anticipated to begin in the early 1980's for medium-sized industrial units and in the mid-1980's for large-sized utility units. In this manner high sulfur coals will be able to be used in an economic and environmentally acceptable manner.

Combustors for coal-oil mixtures are expected to be developed in a few years and retrofit systems should begin to be implemented toward the end of this decade.

Accomplishments: The 30 megawatt atmospheric, fluidized-bed boiler project, located at the Monongahela Power Company plant at Rivesville, West Virginia, began operation in FY 1977 and will continue in FY 1978. This work has verified light off procedures and provided heat and material balances for use in verifying engineering design calculations so that work on the utility demonstration plant can progress. While early testing is not sufficient for determining long-term materials qualifications, data is being obtained on materials behavior in fluidized-bed combustors which will aid in the selection of materials for both industrial and utility applications.

Architect-engineer contractors were selected for the atmospheric and pressurized fluidized-bed combustion Component Test and Integration Units. Detailed designs for both facilities are now underway, with construction to be initiated in FY 1978.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

The Fluidized-Bed Combustion Industrial Applications program has selected eight contractors to design systems which are to be built in industrial and institutional facilities. The program will demonstrate the application of the fluidized-bed combustion process in heating a variety of fluids. This program is being cost-shared with the industrial participants to assure near-term implementation of this equipment.

A Program Opportunity Notice was issued in FY 1977 for the design and construction of industrial/utility applications for the atmospheric fluidized-bed combustion concept using anthracite and/or anthracite culm material as a fuel source. This is a cost-shared program with near-term commercialization potential.

The pressurized, fluidized-bed program includes the design of a combined cycle pilot plant of approximately 13 megawatt capacity which was initiated in FY 1976. Construction of the pilot plant will begin during FY 1978. It will be located at Woodbridge, New Jersey. This project is one-third cost-shared by industry. Fossil Energy will also participate in a pressurized coal combustor research project jointly funded in equal shares by the United States, the United Kingdom and the Federal Republic of Germany, under the auspices of the International Energy Agency. Laboratory and process development units are providing data on combustion, suppression of pollutants in emissions, materials, and component design.

Multiple contracts were awarded during the Transition Quarter and FY 1977 to modify or retrofit, operate and test existing boilers, heaters and furnaces, and to design, construct, operate and test a prototype coal-oil slurry mix/distribution system to demonstrate combustion technology and to evaluate the practicality and economics of burning coal-oil slurries as a primary fuel in place of oil and gas. These contracts are all cost-shared projects.

In addition to the above projects, laboratory studies, other feasibility studies, systems analyses, etc., are underway in support of the development programs for atmospheric and pressurized bed boilers.

Budget Request:

The FY 1978 request for budget authority is $53,200,000, an increase of $1,299,000 over the FY 1977 level. This level will support testing and modifications of the 30 MW multi-cell boiler and will provide data for the utility demonstration plants. Fabrication of several prototype systems in the industrial and institutional fluidized bed combustion application program will continue in FY 1978. These prototypes will lead to commercial applications promptly, as curtailments of natural gas and the cost and uncertainty of oil supply create the need for equipment to burn coal cleanly. These units are anticipated to lead to commercial implementation after a year or more of shakedown and testing. In the FY 1978 period, construction activities on the component test and integration facilities, for both atmospheric and pressurized fluidized-bed combustion systems, will be at their peak. These facilities will provide the capability for developmental testing of improved components and for system configuration research. The pressurized fluidized-bed combined cycle pilot plant will continue with construction of the plant scheduled to begin in FY 1978.

Fluidized-bed plants lend themselves not only to utilities and to industrial and institutional application, but also to coal conversion processes in that they can utilize the char byproduct of coal conversion for increased overall plant efficiency at power generation sites, using fluidized-bed combustors, as well as allowing for a fully integrated self-sufficient type of operation.

a. Fluidized-Bed Boiler, Atmospheric. The prime purpose of this program is to develop atmospheric fluidized-bed systems capable of burning high-sulfur coals of all degrees of rank and quality directly in fluidized bed combustors in an environmentally acceptable manner for utility, industrial and institutional applications. The technology involved in the atmospheric pressure systems is being developed for commercial implementation in the mid-1980's.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
(1) Fluidized-Bed Boiler, 30 MW.....	$ 3,000	$ 4,000	+ $ 1,000

An atmospheric pressure, multi-cell, fluidized-bed boiler has been designed and constructed for the 30 MW program. The boiler with a steam capacity of 300,000 pounds per hour is intended as a method of burning coals of high sulfur or corrosive qualities, while meeting New Source Performance Standards for emission without the need for scrubbers. The boiler is installed at the Monongahela Power Company plant at Rivesville, West Virginia. After a shakedown in FY 1977, the boiler will be used in a test program to verify design engineering procedures, performance as a boiler, reduction of sulfur dioxide and nitrogen oxide emission from the combustor, and the adequacy of auxiliary equipment. The increased funding is required to support this program through FY 1978 for long term testing for verification of materials selection and component life, and to provide data for use in the utility demonstration program. The total estimated cost of the 30 MW Fluidized-Bed Boiler Project is $42,600,000.

(2) Industrial Applications.....	$10,000	$10,000	$ 0

This program consists of the development and demonstration of boilers and heaters employing the atmospheric pressure fludized-bed combustion process. High pressure and low pressure steam generation and air process fluids heating will be studied to determine the practicality and economics of using these applications of atmospheric pressure fluidized-bed combustion systems in industry and in institutional environments, using coal as the primary fuel.

The several systems proposed are needed to closely parallel operating situations and alternative component configurations for comparison and technology development. The projects are in the design phase and two are starting construction. All projects will be cost-shared.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(3) Component Test and Integration Unit (AFB-CTIU).....	$ 4,365	$ 5,500	+ $ 1,135

This Component Test and Integration Unit, to be located at the Morgantown Energy Research Center, will be used to test new atmospheric fluidized-bed combustion systems and improved components at an intermediate size scale and to perfect the process. The development of improved components will provide technical basis for equipment for the Fluidized Bed Utility Demonstration Plant. The increased FY 1978 funding is required for fabrication and field erection in FY 1978. Operation will start in FY 1979.

(4) Modular Integrated Utility System (MIUS).....	$ 1,700	$ 2,000	+$ 300

Project MIUS is authorized by the Housing and Urban Development Act of 1970 (P.L. 91-609). The program is being conducted as a cooperative study by HUD, NASA, DOD, National Bureau of Standards, HEW, as well as ERDA, to determine combined processing plants within a community to use residual or recycle energy for heating, air conditioning, and generation of electricity. A small coal-fired fluid bed combined cycle powerplant will be developed as a demonstration for this project. The design phase was completed, leading to initiation of construction in FY 1977. Construction is expected to be completed in FY 1979 when testing will commence. The 2-year testing period is planned to be completed in FY 1981 at which time operational data will be available leading to commercialization of the coal-fired total energy system. The slight increase in FY 1978 funding is required to support the construction phase of this project. This system will also have application to industrial cogeneration of power and heat in modest size installations. During FY 1978 we will initiate design studies for industrial applications.

(5) Plant Conversion.....	$ 1,100	$ 0	- $ 1,100

This project will evaluate the applicability of using atmospheric pressure fluidized-bed combustion concepts in converting existing power generation systems, emphasizing 10 to 20 year-old plants with the greatest environmental impact, to environmentally acceptable and economically feasible systems. The feasibility study and the preliminary design were initiated during FY 1977 will continue in FY 1978 with studies to determine site requirements for plant conversion and the extent to which boiler integration requirements are generic rather than plant specific. This program will use detailed design information from the utility demonstration program, which will not be available until late FY 1978, to obtain costs for plant conversions. Therefore, no budget authority is required for FY 1978. If practical and economically attractive, this program could lead to a plant conversion project in FY 1980.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(6) Anthracite Applications	$ 1,000	$ 0	- $ 1,000

The purpose of this project is to develop and demonstrate the use of anthracite and/or anthracite culm as a fuel source for industrial/utility application of the atmospheric fluidized-bed combustion concept. A Program Opportunity Notice was issued in FY 1977. The major activity in FY 1977 was the evaluation of proposals and selection of potential contractors. The effort during FY 1978 will be the conceptual design phase, which will proceed to prototype equipment development when data is available from the industrial applications program. No new budget authority is required for FY 1978. The program will be cost shared in the construction and operation phases.

b. Pressurized Systems. Pressurization of the fluidized-bed combustor is a means of increasing power generation efficiency of reducing nitrogen oxide emission and requiring less sorbent for sulfur dioxide emission suppression and of possibly reducing equipment and power generation costs. The basic technology is that the coal and bed material is injected into a pressurized combustion chamber where it is burned in a bed of sorbent. The system operates as a combined cycle, gas turbine-steam turbine plant. The pressurized system further reduces the size of the combustor and, thus, the capital cost. The use of combined cycle systems increases the efficiency of the overall plant. Objectives for the pressurized program are similar to the atmospheric, except that developmental problems are greater and more complex, and the first commercial units would be realized at a later date. Limited tests of American coals were performed in a 5-6 atmospheres pressure test unit at Leatherhead, England, and have shown that this approach is feasible from a technical standpoint. Additional work is required and being performed in order to accomplish the cleanup of the hot gases produced from pressurized fluidized-bed combustion to produce the high turbine reliability and long life required for practical power generation application, and for control of emissions to the atmosphere.

(1) Fluidized-Bed Combined Cycle Pilot Plant	$ 6,000	$ 7,000	+ $ 1,000

The objective of this program is to conduct a pilot plant test program to evaluate the validity of a commercial powerplant design concept. The project was initiated in FY 1976 with a study of comparative commercial systems.

A preliminary design of the pilot plant was completed in FY 1977. Phase II is the detailed design of the pilot plant to be completed in early FY 1978. Phase III, construction of the pilot plant and shakedown testing, will occur in FY 1978 and 1979. Phase IV, operational testing and evaluation, will be performed in FY 1980 through FY 1982 and outyears. The program will be cost-shared in the construction and operation phase by Curtiss-Wright Corporation.

This project includes the design, construction and operation of a 13 MW coal-fired pressurized fluidized-bed combustor/combined cycle pilot plant to be located in Woodridge, New Jersey. This prototype unit is to be designed as a basic element of a central station powerplant so that operating, engineering and economic data can be fully evaluated. The increased FY 1978 funding is required to enter the construction phase of the Fluidized-Bed Combined Cycle pilot plant. The total estimated cost of the project is $50,000,000, of which $5,000,000 will be contributed by Curtiss-Wright Corporation.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(2) Pressurized, Fluidized-Bed Technology.....	$ 1,600	$ 0	- $ 1,600

Production of electric power using coal by means of the Pressurized Fluidized-Bed Combined Cycle offers the potential of providing low-cost electrical power through higher powerplant efficiency. In order to meet the national goal of the commercialization of fluidized-bed boiler technology on a timely schedule, it is essential that the government assure that the pressurized fluidized-bed combined cycle options for electrical power generation using coal are available. Therefore, pressurized fluidized-bed back-up technology for complementary and alternative concepts will be studied in parallel with the pilot plant. This project was funded in FY 1977, with project studies to be completed in FY 1978. Components defined by this technology study will be developed in the pressurized, fluidized-bed component test and integration unit. The program was funded in FY 1977 for work which will continue in FY 1978. Future year efforts will depend on the results of the current efforts and may continue either as part of the engineering studies program or as a separate program depending on the size of the program and the prospects for significant technology advancement.

(3) Component Test and Integration Unit (PFB-CTIU).....	$ 5,100	$ 4,729	- $ 371

This project includes the design, construction and operation of a pressurized fluidized-bed component test and integration unit. The objective is to develop components for pressurized fluidized-bed boilers and powerplants. Processes and equipment state-of-the-art advancements will be integrated to enhance the pressurized fluidized-bed process. The design of the CTIU was initiated in the Transition Quarter at Argonne National Laboratory, Chicago, Illinois, with fabrication and field erection scheduled for FY 1978, followed by operation in FY 1979.

(4) Granular Bed Filter/Hot Gas Cleanup.....	$ 1,500	$ 1,500	$ 0

Experiments with granular bed filters and other hot-gas particle cleanup systems will proceed in FY 1978 to obtain data on the performance of granular bed filters when used as hot-gas particulate removal equipment to clean coal pressurized fluidized-bed combustion to a level suitable for power generation power turbine operation.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
(5) International Energy Administration	$ 3,000	$ 2,000	$ 1,000

International Energy Agency Pressurized Combustor: At the request of the State Department, ERDA is cooperating in the program of the International Energy Agency (IEA). The three participating nations, the United States, the United Kingdom and the Federal Republic of Germany, plan to jointly fund the construction and operation of a 2 meter by 2 meter pressurized fluidized-bed combustor to be located in the United Kingdom. Primarily it will provide data directed toward the development of pressurized industrial boilers. The British team that will build and operate this unit has been in the forefront of research on pressurized fluidized-bed combustion for many years, and their new facility will provide an additional site to complement the limited number of pressurized fluidized-bed facilities capable of performing experiments on industrial scale combustors in this country.

The IEA facility will be used to provide scientific combustion research information on pressurized fluidized-bed combustion of world-wide coals and limestones with configurations appropriate for commercial applications. The IEA facility will provide data on combustor performance while the Component Test and Integration Unit (CTIU) planned to be built in the United States will enable ERDA to qualify auxiliary components and test our systems controls. In addition, the IEA facility will use boiler tube geometries different from the CTIU, thereby evaluating a viable alternative design and providing information on the relationship of combustion and mixing rates to variations in internal combustor design.

In addition, the cost sharing arrangement with the other supporting nations provides an additional large scale scientific research facility at only a fraction of the cost to the United States of a domestic ERDA funded facility. The test program to be performed will be decided upon by the supporting nations and all data will be made available as rapidly as possible. FY 1978 funding is required for ERDA's share of support costs for the IEA project.

c. Coal Oil Slurries	$ 4,300	$ 7,000	+ $ 2,700

The combustion of coal-oil slurries in existing oil and gas-fired combustors will be investigated to determine the extent to which this technology can be implemented in a practical manner to substitute coal for an appreciable fraction of gas and oil in appropriate industrial and utility combustors within the near future. Test equipment will be installed and operated at the Pittsburgh Energy Research Center.

Multiple contracts were awarded during the Transition Quarter and FY 1977 for the demonstration of industrial and utility applications of coal-oil slurry as a primary fuel. The objectives of these awards are to modify or retrofit, operate and test existing boilers, heaters and furnaces to demonstrate coal oil slurry combustion technology. The goal is to substitute coal for an appreciable fraction of oil and gas in appropriate industrial and utility combustors within the near-term. It is anticipated that these efforts will be a key step in identifying those systems best suited to conversion; validating conversion costs, regional dependency and its consequent economics; and determining the near-term applicability of coal-oil slurry as a primary fuel and a valid article of trade.

In addition, mechanical emulsifier application will be investigated. Market and economic evaluations of the program will begin in late FY 1977. The FY 1978 funding is required to realize the near-term benefit of this technology as part of the national priority for energy independence.

d. Support Studies and Engineering Evaluations. Laboratory and design studies now in progress support the direct combustion development projects. These studies are designed to promote optimum coal utilization by supplying data essential for application of direct combustion units to public utility and industrial systems.

Key components of the total system, including processing, handling and transport equipment, will be considered in the context of operability and design optimization. Component corrosion and fouling studies will be made, and methods will be developed for minimizing these problems. Optimum design of combustors capable of efficiently burning synthetic fuels will be promoted by characterizing fuels such as chars, coal wastes, low-Btu gas, solvent refined coal and synthetic liquid fuels in terms of heat transfer and combustion properties.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(1) Engineering Studies	$ 5,101	$ 4,471	- $ 630

Very little is known concerning the emission characteristics, slagging and corrosion characteristics of the synthetic fuels now being developed. Such data is essential, however, for design of new combustors and boilers for such fuels, as well as combustion improvement for existing fossil fuels. Present boiler operational practices result in significant deposits of ash and slag on boiler tubes, which cause a reduction in heat transfer and corrosion. ERDA's National Laboratories and Energy Research Centers will conduct studies on restriction of fireside tube fouling and on combustion characteristics.

FY 1978 funding is required to support feasibility studies, system analyses, etc., to develop and experimentally establish an analytical model of the elemental processes of fluidized-bed combustion in boilers in order to establish a better

understanding of the fundamental process, including their use for advanced conversion systems. This fluidized-bed combustion modeling activity will be used to correlate design and performance characteristics of both atmospheric and pressurized systems with a variety of internal components so as to provide an improved engineering basis for future development and commercial units. Program planning, engineering, and economic evaluation of complete systems are being performed so that the development program leads to equipment and systems which can be operated by users and can be fabricated practically by industry. New technologies in direct combustion and gas cleanup are being investigated.

		Budget Authority		
		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
(2)	Non-Fluidized-Bed Combustion	$ 1,500	$ 3,000	+ $ 1,500

The purpose of this project is to demonstrate increased availability, reliability and efficiency of existing coal fired utility and industrial systems. Emphasis in this program will be on improving the ability to burn low sulfur, high ash Western coals in boilers designed to burn Eastern coals with different ash, combustion, slagging and particulate characteristics. The benefits of this program are lower costs for expansion of utility plants to cover for the reduced availability now occurring due to the use of coal different than for which the boiler was designed and the ability to better utilize equipment in place and conventional off-the-shelf, combustion equipment. The program will proceed with the feasibility and design portion of the program in FY 1977. Increased FY 1978 funding is required for the hardware procurement phase of this project.

(3)	Environmental Studies, Other Support and Special Projects	$ 2,635	$ 2,000	- $ 635

Other Support. The objective of this effort is to provide configuration performance and cost estimates of commercial versions of technologies under development, support of project planning, design, construction and test monitoring and data evaluation, and the development and integration of R&D technical programs. This effort will provide the overall perspective of the various technologies from the user's viewpoint, the relationship of the technologies being developed, recommendations for specific activities to enhance the data being obtained from the program, and recommendations for alternative courses of action necessary to achieve short, mid, and long-range goals.

Environmental Studies. Environmental studies is a newly defined effort to support generic studies applicable to many or all direct combustion projects and to provide support to new projects starts. Such studies will consist of, but are not limited to, environmental assessments, process emissions and effluent characterization.

Another program will continue in cooperation with the U.S. Department of Agriculture, to evaluate the effectiveness of fluidized-bed combustion waste materials for use in the following areas: (1) strip mine reclamation; (2) improving production and quality of forage and marginal lands; (3) maintenance of proper pH in farm lands; and (4) provide a source of calcium in horticultural crops.

DIRECT COMBUSTION
SUMMARY OF PILOT PLANTS, PDU'S, AND MAJOR HARDWARE FABRICATION

	Location	TEC	Cumulative Prior Year	FY 1977 Estimate	FY 1978 Estimate	Cumulative Future Year
Fluidized-Bed Boiler, 30 MW	Rivesville, W. Va.					
ERDA Funding						
Operating Expenses		$ 42,600	$ 23,600	$ 3,000	$ 4,000	$ 12,000
a. Design and construction		24,500	22,500	2,000	0	0
b. R&D and operational		18,100	1,100	1,000	4,000	12,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		42,600 1/	23,600	3,000	4,000	12,000
Total Project Funding		$ 42,600	$ 23,600	$ 3,000	$ 4,000	$ 12,000
Fluidized-Bed Combined Cycle Pilot Plant	Wood Ridge, N.J.					
ERDA Funding						
Operating Expenses		45,000	9,000	6,000	7,000	23,000
a. Design and construction		20,600	7,600	5,000	6,000	2,000
b. R&D and operational		24,400	1,400	1,000	1,000	21,000
Capital Equipment		0	0	0	0	0
Total ERDA Funding		45,000 2/	9,000	6,000	7,000	23,000
Curtiss-Wright Corp. Funding		5,000 3/	0	0	0	5,000
Total Project Funding		$ 50,000	$ 9,000	$ 6,000	$ 7,000	$ 28,000

1/ Based on contract and estimated operational costs.
2/ Based on conceptual design and contract.
3/ Based on contract.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
6. Advanced Research and Supporting Technology	BA	$ 37,070	$ 40,000	+ $ 2,930
	BO	36,570	42,000	+ $ 5,430

Objectives:

The Advanced Research and Supporting Technology subprogram serves as the central research and systems studies area for all elements of Fossil Energy. The major objectives of this subprogram are to:

Explore and develop through an initial development stage new and advanced processes for the conversion of coal to clean synthetic fuels and chemical feedstocks;

Assure reliable and efficient operation of synthetic fuel plants through materials and components research;

Investigate and develop advanced techniques and support technology for direct utilization of coal;

Supply technically trained personnel for future coal conversion industries by promoting such research in the nation's academic communities;

Conduct analyses of fossil energy processes, technologies and systems, and to formulate planning and policy options for management decision making.

Accomplishments:

A major accomplishment in FY 1977 is the completion of tests on several advanced process and materials research projects in a diversity of highly qualified university, government, and industrial laboratories. Many of these new projects promise to provide the basis for significantly improved processes - in particular to lower capital costs and increase reliability.

Additional accomplishments are as follows:

a. Materials and Components

Completion of 300-hour laboratory tests in the spring of 1976 of boiler tubing alloys operating at steam temperatures greater than the normally used 1050°F, indicating no accelerated wastage; field testing to a maximum of one year of these alloys is now in progress.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

Failure information and prevention center for coal conversion plants established.

Programs initiated on materials for pressure vessels and on corrosion/erosion resistant coatings.

Extensive continuing research for the development of valves capable of operating reliably for long period of time under severe wear, erosion, and corrosion conditions in coal conversion processes.

Continue failure analysis and non-destructive testing services for coal conversion and utilization pilot plants.

Valve test laboratory established at Morgantown Energy Research Center to test newly developed valves operating in simulated environments of coal conversion plants utilizing various processes.

Materials and Components Newsletter expanded to bi-monthly publication to better serve approximately 2,500 subscribers, 70% of whom are in private industry.

b. Processes.

Completion of the experimental evaluation of a novel and advanced catalytic coal gasification process for producing high yields of synthetic natural gas (SNG) in the gasifier.

Completion of the experimental evaluation of a novel extractive coking process for clean boiler fuel of potentially low capital cost.

Completion of the experimental evaluation of a flash hydropyrolysis study of high hydrogen pressure to produce a light distillate product and SNG in one step at very high throughput rates.

Completion of laboratory evaluation of "cross-flow" filtration for separation of SRC from the liquefaction process stream at significantly higher throughput rates than state-of-the-art processes.

Definition of the technical problems and economic assessment of adapting advanced petroleum technology to refining coal syncrudes to transportation fuels.

Completion of Phase I (defining process conditions and economic parameters) in bench scale investigation of a novel and superior Fischer-Tropsch process for converting synthesis gas from coal to high octane gasoline in one step.

Determination of the rates of removal from coal of different forms of sulfur under non-catalytic liquefaction conditions.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

c. Direct Utilization

Initiation of a significant coal pre-conversion program, including (a) instrumentation development for preconversion monitoring and (b) research toward advanced benefication processes.

Demonstration that treatment of coal by ammonia results in efficient comminution of coal without generation of troublesome fine particles.

Bench-scale testing of coal combustion to the point where quantitative criteria for fouling potential have been developed and are being transferred to industry.

Initiation of a bench-scale fluid bed program to study the feasibility of increasing the combustion temperature and thus the cycle efficiency. Laboratory scale demonstration of a novel sulfur sorbent/regenerant system for fluid-bed combustion of coal.

Initiation of an advanced feasibility study of centrifugal hot gas cleanup.

Initiation of basic support studies on: (a) burner stability of low-Btu gases; (b) turbulence diagnostic for combustor modelling; (c) in situ identification of ash-fouling chemical species.

Bench-scale combustor evaluation of a two-stage process for reduction of nitrogen oxide formation in the combustion of coal.

d. Program Development and Coordination

This budget category was formerly titled "Systems Studies" and has been renamed to reflect the activities conducted to support improved management of the Fossil Energy program. Accomplishments in FY 1977 include:

Developed integrated Fossil Energy planning system, including the Fossil Energy program plan, program planning documents (Annual Program Plan and Volumes I and II of ERDA's Annual Plan), contingency plans, and Program Approval Documents.

Developed the concepts for an improved management plan for enhanced oil recovery, and provided supporting analysis of the yield potential and economics of enhanced oil recovery.

Developed the concepts for a Fossil Energy coal preparation program.

Completed study of the net energy usage of selected combinations of technologies from energy source to end use.

Completed development and testing of operational computer models for estimating costs of large scale mining including coal preparation.

Conducted transportation study comparing costs of coal transport by unit trains, slurry pipelines and barges.

Performed 20 process evaluations, both from a technical and engineering viewpoint, on coal gasification and liquefaction, in situ gasification, oil shale conversion and enhanced oil and gas recovery.

Developed an engineering residency program to utilize professional engineers from universities and industry to assist in the evaluation of technologies, to improve the planning of Fossil Energy RD&D and to enhance the transfer of technology between ERDA and the engineering community.

Completed environmental statement for Coal R&D Program.

Completed key studies to reduce water consumption of Fossil Energy facilities. Prepared guidelines for site selection procedures.

Developed guidelines and methodologies for preparing environmental development plans.

Initiated environmental development plans for coal conversion, coal utilization, MHD and enhanced oil recovery.

Budget Request

	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Materials and Components	$ 8,585	$ 9,264	+ $ 679

Advanced coal conversion plants are designed to operate at higher efficiencies than those commercially available and thereby convert a larger fraction of the primary energy (coal) into useful products. Higher efficiencies place greater demands on the materials and components because the operating conditions are more severe in termsof temperature, pressure, and chemical environment. At the same time, economic factors dictate that the materials be inexpensive to reduce the initial investment costs but operate reliably without failure, to reduce operating costs. The materials and components effort will continue to generate a data base, via quantitative controlled laboratory and pilot plant experimentation, that will allow industry to make the proper tradeoff between plant costs and reliability, as well as develop new materials and components for increased plant operability.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

1. Materials. The materials activity is in three major areas:

   (a) Materials Evaluation to provide engineering design data, critically needed for coal conversion pilot and demonstration plants:

   Currently available materials of construction will be exposed to coal conversion pilot plant environments to determine how well they will withstand the new processing conditions.

   Laboratory tests will be conducted to determine design data for materials proposed for internal parts of new, second generation coal gasifiers.

   Refractory-lined gasifier walls will be evaluated in laboratory tests to develop reliable engineering design data.

   Fracture toughness properties of pressure vessel steels will be determined so they can be qualified, under a pressure vessel code, for use in coal conversion plants.

   (b) Materials R&D to provide new and improved durable, low-cost materials of construction for coal-conversion plants:

   Laboratory studies will be conducted to develop low-cost alloys resistant to the corrosive, sulfurous environments present in second generation conversion plants.

   Automated welding techniques wil be developed for field fabrication of gasifier pressure vessels to significantly lower field erection costs.

   Coatings will be developed for protecting gasifier internal parts from the corrosive environments.

   Standard test methods will be developed for refractory materials used in high temperature gasification.

   (c) Materials Technology Transfer to Industry:

   Root causes of materials failures in coal conversion pilot plants will be determined. The failure analysis data wil be compiled and disseminated to industry to prevent recurrences.

   A monthly ERDA Materials Newsletter will be published to inform all interested parties of latest developments in materials evaluation, alloy developments, and failures analysis.

2. Components. This activity is devoted to developing means of feeding coal into high pressure reaction vessels. In addition, innovative components are being developed to assure plentiful supplies of oxygen for conversion plants.

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A prototype valve test facility will be constructed.

State-of-the-art valves will be tested in a special facility designed for the unique chemical physical environments of coal conversion.

Prototype advanced valves will be tested to determine total service costs.

Construction and testing of equipment to confirm novel oxygen compressor design.

	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
b. Processes	$ 15,200	$ 16,401	+ $ 1,201

The research on processes entails a three-pronged approach involving basic, exploratory, and supporting process research with heavy reliance on the university community.

(1) Supporting process research to facilitate the successful development of second generation processes, e.g., improved catalysts for hydroliquefaction, catalytic methanation, and refining of syncrudes using conventional petroleum refinery technology.

(2) Exploratory research on new process concepts leading to major reductions in capital and operating costs, with improved operational realiability, e.g., catalytic gasification, flash hydropyrolysis.

(3) Basic research on various coal gasification and liquefaction phenomena to provide basic insights leading to new and advanced process concepts.

(4) The university community will provide important contributions to this program through its special capabilities to perform basic and innovative coal research. In addition, a major function of this research support is ensuring an adequate base of technical manpower trained in coal science and technology.

Specific research efforts on gases, liquids, and refining and chemicals are described below:

(1) Gases Process Research. Specific research during FY 1978 includes completion of bench-scale evaluation and economic assessment of (a) a novel catalytic coal gasification SNG process, (b) a caustic/lime - activated coal gasification SNG process, and (c) a novel improved Fischer-Tropsch process for the conversion of synthesis gas in one step directly to gasoline. In addition, research will be initiated to develop a practical advanced gasification process for hydrogen via synthesis gas from coal liquefaction residua, coal, or coke.

(2) Liquids Process Research. Specific research during FY 1978 includes completion of exploratory research on (a) an advanced low pressure Bergius process employing a disposable molybdenum oxide/bauxite catalyst, and (b) a riser cracking process for the conversion of coal to a BTX-distillate gasoline blending feedstock and SNG; experimental evaluation of the technical and economic potential for a unique delayed coking process for coal/petroleum residua slurries to a coker distillate for subsequent fluid catalytic cracking to a motor fuel blending stock; and development of promising catalysts for the Synthoil and H-Coal processes. In addition, research will be initiated (or continued) on the development of a practical process for separating ash from SRC; and evaluation of novel process concepts.

(3) Refining and Chemicals Process Research. The research during FY 1978 involves completion of evaluation of advanced petroleum catalyst technology for upgrading different syncrudes from coal and oil shale to transportation fuels, including the costing of a refinery for a candidate syncrude; development of advanced catalysts for upgrading Synthoil and H-Coal syncrudes to high quality distillate fuels; and engine testing of selected distillate fractions, neat and blended with gasoline, from refined syncrudes.

	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
c. Direct Utilization	$ 5,535	$ 5,972	+ $ 437

The following efforts will be made in FY 1978:

(a) Combustion studies of pulverized coal with emphasis on characterization of pollutant emissions and search for combustor parameters minimizing emissions.

(b) Energy transfer: A study of new concepts for heat transfer in fluid-bed combustors.

(c) Cleanup of coal/oil slurry combustion products.

(d) Scale-up of the ammonia comminution process.

(e) Limited studies toward hot-gas cleanup will be continued.

(f) Research toward utilization of waste products.

d. Program Development and Coordination	$ 7,750	$ 8,363	+ $ 613

The FY 1978 budget request for this category of $8,363,000 represents an increase of $613,000 over the FY 1977 level. The funds requested will be used to appropriately continue the selected activities described under Section d of the Accomplish-

ments, as well as for the initiatives described below. These efforts are designed to provide coherent and integrated direction to the Fossil Energy program and help establish the technical base required for management decisions. Activities in FY 1978 will be carried out in the following general areas:

Planning. Continue the development of Fossil Energy plans, strategies and rationale needed for program direction and policy analysis including: analysis of market applications and requirements for fossil energy products; analysis of the effect of transportation on the competitiveness of synthetic fuels in energy markets; and means to expedite the transfer of fossil energy technology to commercial use. The FY 1978 request of $2,323,000 provides for the continuation of these efforts with emphasis on implementing benefit/cost analysis methodology and permits interactions with State and local governments on the regional aspects of fossil energy requirements. These projects would provide the analytical bases for the RD&D strategy through market penetration studies, analyses of technological priorities, economics and system analyses, and macro-economic forecasts.

Financial Management. Continue the development of integrated Fossil Energy programs and budgets within the planning and strategic framework established. The FY 1978 request of $500,000 provides for the continuation of these efforts while providing for the full implementation and operation of a financial information system started in FY 1977.

Environment and Safety. Continue efforts to comply with the National Environmental Policy Act (NEPA), the Non-Nuclear Energy R&D Act, and all applicable laws and regulations pertaining to the environment, health and safety. The FY 1978 request of $2,770,000 provides for the development of Environmental Development Plans, the initiation of added efforts for occupational safety and health assurance, and establishment of an environmental monitoring program to assure compliance with NEPA. The funds requested for environment and safety are small in relation to pilot and demonstration plant costs; yet these projects cannot proceed without adequate environmental treatment.

Reviews and Analysis. Continue process design and economic analysis of Fossil Energy recovery and conversion technologies, including coal, oil shale, petroleum, natural gas and heavy oils. In addition, an analysis of the coal conversion technologies of other nations will be maintained. The FY 1978 request of $2,770,000 provides for analytical model development, staffing of an Engineering Residency program, the start of a Program Coordination Team effort and the start of Program Assurance System (PAS).

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
7. Demonstration Plants	B/A	$ 53,000	$ 40,900	- $ 12,100
	B/O	50,600	28,700	- 21,900

Objectives:

The goal of the Demonstration Plant subprogram is to demonstrate, on a near-commercial scale, those selected second generation synthetic fuel conversion processes that have been developed and evaluated through industry and government research and development. The subprogram is the final step in the R&D process aimed at accelerating and reducing the risks of industrial process implementation. Engineering construction and operation of demonstration plants are jointly funded by government and industry; this will promote near term commercialization. Specific objectives include:

- Indicate the technical and economic viability of candidate processes.
- Stimulate the interest of private industry in proceeding with related research, development and commercialization.
- Accelerate the development of specialized equipment, facilities and skills.
- Establish the applicability of developmental coal conversion processes to the range of U.S. coal ranks.
- Establish an extensive technology data base within the public domain.
- Verify the environmental acceptability and adequacy of emission controls for each demonstrated technology.

Programmatic strategy for achieving the objectives is based upon cooperation between Government and industry. It is designed to insure demonstration of all fuel technologies related to the growth of a synthetic fuels industry. The specific strategy for each process technology selected for demonstration must also reflect market need, environmental and socioeconomic impacts, and legal and institutional requirements, as well as providing incentive for industry participation. The strategy encompasses consumer and regionally oriented development of energy technology. The timely dissemination of information will foster an orderly transfer of technology to the public domain.

Financial strategy will require industry participation in the initial phases of the project including conceptual commercial plant designs, and co-funding (target goal of 50/50) with industry during the detailed design, construction and operation of the demonstration plant. The specific cost-sharing strategy is determined for each project, but the option is retained for funding more than one contractor to accomplish the goals established by the work statement. The cost-sharing approach has been selected because it permits Government participation in the design while encouraging active management participation by industry. Each participant for a demonstration plant will be selected from the competitive bidders who respond to a definitive Request for Proposal.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

It is noted that Requests for Proposals for demonstration plants do not constrain offerors to bid only those processes developed through the ERDA Fossil Energy program. All candidate processes, including those developed by industry, may compete, and awards will be made primarily on the basis of technical merit, financial risk, and comparative process economics.

For each proposed project, the contractor prepares a conceptual commercial design for the process of his choosing. This design provides the basis for the demonstration plant design, and insures that all elements of a commercial plant are included in the demonstration plant itself. The design also includes preparation of capital and operating cost estimates, from which a projected selling price of product can be determined. That price is an important criterion for selection of candidate demonstration plants. Demonstration plants have been chosen in fuel technology areas which have the potential for significant near-term impact. Plant types which have been identified to date include: Liquid Fuels, Pipeline Gas, Fuel Gas, and Direct Combustion. Unless it is feasible to go directly to commercial demonstration, at least one demonstration plant of each type is planned for construction and operation before 1985.

Accomplishments:

The Demonstration Plants subprogram is divided into five categories:

Clean Boiler Fuel Demonstration Plant. Process design and environmental studies for the conceptual design will be partially completed by July 1977. The lack of data needed to produce a process design has delayed completion of the Phase I effort. Efforts will be initiated in FY 1977 under the Coal Liquefaction subprogram to obtain the necessary design data through the use of small scale test facilities.

High-Btu Pipeline Gas Demonstration Plant. During FY 1977 an evaluation was made of five proposals received in response to ERDA's RFP. Contractors selected will begin conceptual design studies of commercial plants in order to refine estimates of process integrity and economics.

Low-Btu Fuel Gas Demonstration Plant. During FY 1977 an evaluation was made of twelve proposals received. Contractors have been selected, who will begin conceptual design studies about mid-FY 1977.

Direct Combustion Demonstration Plant. Two planning level concept design awards were made to process engineering firms during FY 1976. These will continue through FY 1977 and be completed in FY 1978. During FY 1977, a Source Evaluation Board will be formed to direct the procurement necessary for award in FY 1978 of Direct Combustion Demonstration Plant project designs.

Design and Technical Support. Several concept designs (e.g., Coal-Oil-Gas; Methanol Facility or Advanced Liquefaction Plant) will be completed, and others considered for selection. Equipment development and component and equipment testing, including valves, coal feeders, materials, etc., will be accelerated. Technical and management support will continue in response to the growing needs of the Demonstration Plant projects.

Budget Request

The FY 1978 request for $40,900,000 in budget authority for Operating Expenses is a decrease of $12,100,000 from the FY 1977 level. The decrease reflects the scheduled completion of the conceptual design phase of several projects, as well as a significant lessening of emphasis on Design and Technical Support activities.

		Budget Authority		
		Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
a.	Clean Boiler Fuel Demonstration Plant	$ 0	$ 0	$ 0

No new budget authority is requested in FY 1978 for this project. The lack of data needed to produce a process design has delayed completion of the Phase I effort.

b.	High-Btu Synthetic Pipeline Gas Demonstration Plant	$ 10,000	$ 5,000	- $ 5,000

The decrease of $5,000,000 in Operating Expenses reflects the scheduled completion of concept designs in FY 1977. The $5,000,000 request will support a continuation of environmental analyses, engineering evaluations and testing, and project management activities. In addition, the FY 1978 Plant and Capital Equipment appropriation contains $29,000,000 which is required to continue design and construction, and related activities for a demonstration plant.

c.	Low-Btu Fuel Gas Demonstration Plant	$ 12,000	$ 4,500	- $ 7,500

The reduction in the level of funding reflects the completion of concept designs in FY 1977. The purpose of this project is to validate the feasibility of using a low-Btu coal gasifier as a source of energy or feedstock. FY 1978 funds are requested for environmental analyses, engineering evaluation and testing, and management support activities. The FY 1978 Plant and Capital Equipment appropriation of $36,000,000 is requested to support plant design efforts, long-lead commitments for capital equipment, and to initiate construction of a demonstration plant to furnish clean fuel gas to an industrial user.

d.	Low-Btu Fuel Gas Small Industrial Demonstration Plants	$ 0	$ 4,000	+ $ 4,000

The objective of this project is to validate the feasibility of gasifying high-sulfur and agglomerating coals to produce fuel gas for single industrial users in an environmentally acceptable manner. Two plants are proposed for such applications as (1) direct firing of iron ore pellet shaft furnaces, (2) indirect firing of zinc retort furnaces, and (3) short pipeline distribution systems for general industrial use. The FY 1978 request of $4,000,000 for Operating Expenses would provide for a competitive conceptual plant design effort, engineering evaluation and testing activities, site evaluation, and management support. In addition $6,000,000 requested for Plant and Capital Equipment would allow for start of demonstration plant designs, and initiation of long-lead procurement and preliminary construction activities.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
e. Direct Combustion Demonstration Plant	$ 0	$ 6,000	+ $ 6,000

Project start is proposed for a plant which would demonstrate the feasibility of direct coal burning in a fluidized-bed boiler as a heat source to a central station power plant. This new request will support a competitive design effort for commercial plant concepts. In addition, the FY 1978 Plant and Capital Equipment request of $2,000,000 will permit initiation of demonstration plant design.

f. Design and Technical Support	$ 31,000	$ 21,400	- $ 9,600

This category includes: (1) conceptual design studies which are used to identify candidate demonstration plant projects; (2) development and testing of equipment and components essential in the construction of demonstration plants and ultimately to the scuccess of commercial synthetic fuel plants; and (3) a variety of planning, technical and management support activities that are essential to the success of the Demonstration Plants subprogram. The FY 1978 request of $21,400,000, a reduction of $9,600,000 from the FY 1977 level, will provide for the following activities:

Design Studies ($6,000,000). Conceptual design studies are planning tools in which pilot plant data are used as the basis for developing optimum plant configurations, in terms of matching unit operations, to produce commercially attractive product slates at least cost. These studies provide valuable benchmarks in proposal evaluation, and for planning for candidate demonstration plant projects. This funding request is for both continuation of ongoing studies and new starts.

Equipment Development and Component Testing ($6,000,000). Successful operation of large-scale equipment and components is essential for commercial plant success. There is an array of such equipment, e.g., large valves, coal feeders, which are generic to the operation of all demonstration plants, and which must therefore be developed and tested hand-in-hand with the plants. Funding for this category is largely to continue work previously started.

Engineering Support ($5,000,000). Program technical support will be provided by the National Laboratories, ERCs, U.S. Army Corps of Engineers, Department of the Army Development and Research Command, and various private engineering firms.

Environmental and Socio-economic Studies ($1,400,000). Environmental impact analyses--what the social, ecological, esthetic, and economic impacts of large industrial development might be, and how to balance them--will continue.

Planning and Program Support ($3,000,000). These support activities are largely a continuation of established activities. They include modeling and systems studies, economic and financial analyses, technical reports, and management support.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - continued

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
8. Magnetohydrodynamics (MHD)	B/A	$ 34,990	$ 45,800	+ $ 10,810
	B/O	25,989	33,000	+ 7,011

Objectives:

The objective of the MHD program is to achieve successful operation by the late 1980's of a commercial scale facility to generate electricity from coal or a coal-derived fuel, utilizing MHD generation principles. This objective is being pursued in recognition of the potential higher overall coal to electricity conversion efficiency predicted for this process.

Accomplishments:

The MHD subprogram is divided into two technology categories: open and closed cycle systems. In an open cycle system, the working fluid consists of gaseous combustion products which are eventually exhausted in the atmosphere after all possible energy has been removed by the MHD generator, preheaters, steam boiler and economizers. In a closed cycle system energy is transferred from a heat source to the working fluid (inert gas or liquid metal/vapor mixture) through a heat exchanger. After all possible thermal energy has been extracted, the working fluid is fed back to the beginning of the cycle (recycled). By far the greater emphasis is on open cycle as it is technologically the more advanced and offers greater potential for higher power plant efficiency. Consideration given to closed cycle systems includes exploratory work relating to heat exchanger and generator problems.

Existing MHD technology is not sufficiently advanced to justify direct construction of an experimental utility size plant. Financial risk considerations demand engineering development at subscale prototype levels before proceeding to the major commitments required for commercial application. Intermediate subscale plant sizes have been determined by relevant scaling considerations and involve two facilities: a 50 Megawatt Component Development and Integration Facility (CDIF) and a 250 Megawatt Engineering Test Facility (ETF). The first is already under construction and its completion is expected in 1978. This facility will be used for evaluating coal-fired open cycle prototype components and for focusing on specific design and integration requirements. The CDIF will also be used for the gathering of information upon which to base decisions regarding the design and the timing of the ETF. Additionally, through the current US/USSR agreement on MHD generation, preliminary information on pilot plant operation is becoming available for our use. Laboratory tests and simulation studies conducted by U.S. contractors are also providing engineering experience and design data for prototype component fabrication. Noteworthy are the following achievements: Successful MHD generator operation for 100 hours with moderate slag carryover; improved recovery of seed and slag from the gas stream; identification of promising materials for direct fired preheater application; and progress in preheater durability demonstrated by more than 400 hours run on a tandem configuration in which temperatures achieved were in excess of 3000 degrees F. Impact of these successful experimental accomplishments is to demonstrate tangible progress in (1) generator durability and performance under slagging conditions, (2) development of requisite seed/slag recovery and separation techniques, (3) development of direct fired preheaters required for the highest plant efficiencies, and (4) preheater durability and system operation and control.

The CDIF, at a 50 Megawatt thermal scale, represents the minimum size that can exhibit the critical phenomena and interactions between the various components and which can then be utilized for subsequent scale-up to the ETF. The interrelation of these components is complex and requires simultaneous development of alternative engineering approaches and their testing in a single facility designed to supply maximum information. The examination of critical phenomena associated with their operations will enable a design basis to be selected for the ETF.

The testing of these components and subsystems to be performed in the CDIF begins in 1978. The critical components may be arranged according to their relative importance to the success of the system concept: (1) the MHD generator itself, (2) the MHD core components including combustor, nozzle, and inverters, (3) superconducting magnet, and (4) the balance of the system, including the high temperature air preheater, the seed/slag management subsystems which include the radiant boiler subsystem. The ordering of development and testing priorities tends to follow this arrangement since decisions made at the generator level, for example, can profoundly influence requirements for the core components and balance of plant.

Budget Request:

The FY 1978 request for budget authority is $45,800,000, an increase of $10,810,000 over the FY 1977 level, primarily to continue the component development effort for CDIF test hardware. The increase will be used to (1) maintain primary emphasis on the CDIF by continuing development on an initial power train, carrying forward a superconducting magnet for this facility, and initiating work on a second power train ($7,673,000), (2) continue MHD technology base efforts ($1,533,000),(3) support current ETF conceptual design studies ($600,000), and (4) provide increased systems and design analytical support ($1,370,000). A concurrent decrease of $366,000 in Closed Cycle Systems results in the $10,810,000 overall MHD increase. The CDIF components will represent concepts which can be scalable to ETF size and which can potentially achieve durability, efficiency and cost levels acceptable for commercial MHD applications. Since best, first generation, component designs cannot be selected from among alternatives prior to actual testing, a second power train configuration needs to undergo parallel development for subsequent integrated operation.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Open Cycle Systems	$ 33,890	$ 45,066	+ $ 11,176

The total funding request of $45,066,000 for open cycle systems is divided between five categories currently established for this program: Preliminary Engineering; System Design and Analysis; Component Development; Engineering Test Facility; and Supporting Science and Technology.

The requirements for each of these elements are as follows:

Preliminary Engineering studies supporting component development, especially the resolution of technology issues involved in alternative approaches, will continue using existing facilities and resources and will generally be conducted at a significantly smaller scale than that of the CDIF. Clarification of thermal, electrical, chemical and fluid dynamic behavior related to engineering and system requirements will be emphasized. A total funding of $10,613,000 will be required for these activities which include the following major subdivisions:

Determination of the most appropriate materials of construction and configuration for the MHD generator and other components of the entire flow train (coal feed, seed feed, combustor, radiant boiler, and seed/slag management systems) will continue to receive major attention and will require $4,418,000.

The related areas of the superconducting magnet technology required to ensure the availability of magnetic field systems of appropriate geometry and field strength and high magnetic field phenomena in channels will require $4,950,000 and $1,120,000, respectively.

Conclusion of the MHD generator high performance demonstration experiment will involve $125,000.

System Design and Analysis studies based on computer models will continue to predict individual component performance, systems interaction and optimization requirements. Efforts to improve modeling techniques through experimental correlations will also be conducted. Experimental information will be collected, analyzed, and correlated with theoretical estimates. Technical and analytical support for other categories of the MHD program will be provided. Funds required for this effort total $6,070,000.

Component Development will be continued and will begin integration of key power train subsystems. This activity will address two major objectives: (1) evaluation of alternative component subsystems, particularly the hot gas flow train comprising the combustor, nozzle, channel, diffuser and inverter, on the engineering scale appropriate for long duration operation, and (2) MHD generator channel performance on a scale close to that presently envisaged for the ETF by use of the Soviet U-25 pilot plant, available through the US/USSR Cooperative Program. The intended result of this activity is to provide the necessary engineering design basis for the ETF. Long duration operation and channel performance will be mainly conducted in the CDIF facility. Funds required for this effort total $23,913,000. These funds, in accordance with the objectives of the component development activity, involve the following breakdown:

Flow train development will receive major emphasis and will involve continuation of current efforts as well as initiation of high performance, high magnetic field and long duration operation efforts at a funding of $16,035,000.

Provision of a superconducting magnet at the CDIF will be initiated to ensure that development and testing can be conducted at base load magnetic field conditions and will require $1,500,000.

The design, fabrication and testing of prototype ETF scale hardware for the US/USSR Cooperative Program will also be continued and will require $558,000.

CDIF facility operation and support will require $5,820,000.

Engineering Test Facility (ETF) activities will support conceptual system design definitions and requirements. Studies will be aimed at establishing component and subsystems interfacing and system performance envelopes. Flexibility will be retained since final decisions must await component performance in the CDIF. Funds required for this effort total $600,000.

Supporting Science and Technology will cover the entire base of the open cycle program and will emphasize studies in such areas as MHD analysis, combustion engineering, coal technology, electrode subsystems and seed/slag component interaction physics and chemistry. Funds required for this effort total $3,870,000.

	Budget Authority Estimate FY 1977	Budget Authority Estimate FY 1978	Increase or Decrease
b. Closed Cycle Systems	$ 1,100	$ 734	- $ 366

Efforts will continue to resolve critical issues in connection with the feasibility of plasma closed cycle systems. Isolation of the working fluid from the combustion products demands the superposition of a heat exchanger between the plasma loop and the primary heat source. Process demonstration revolves around two problems, at the present unresolved: heat exchanger durability and high contaminant carryover to the working fluid in the case of a coal-fired heat source. Current heat exchanger experiments will be continued.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Plant and Capital Equipment
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1976	Actual TQ	Estimate FY 1977	Revised Estimate FY 1978
A. Obligations for Construction Projects	$ 14,740	$ 4,600	$ 80,860	$ 86,800
B. Obligations for Capital Equipment Not Related to Construction	0	0	250	2,400
Total Obligations for Plant and Capital Equipment	$ 14,740	$ 4,600	$ 81,110	$ 89,200

Obligations for the Coal Program for FY 1978 are estimated at $89,200,000 of which:

a. $86,800,000 is for the construction projects listed in Section A below, (1) requested for authorization in the proposed Authorization Bill, or (2) were previously authorized and for which a request for appropriation is being made in FY 1978.

b. $2,400,000 is for Capital Equipment Not Related to Construction justified in Section B below, requested for authorization in the proposed Authorization Bill.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

SECTION A - Obligations for Construction Projects

The projects comprising Section A, which are requested for authorization or which were previously authorized and for which a request for appropriation is being made are:

Project No.	Project Title	Total Estimated Cost	Funded Thru TQ	Estimated Obligations FY 1977	Revised Estimated Obligations FY 1978	Future Funding Required to Complete Project
78-2-a	Analytical research, chemistry and coal carbonization laboratory, Pittsburgh Energy Research Center, Pennsylvania	$ 6,600	$ 0	$ 0	$ 6,600	$ 0
78-2-b	Modifications and additions to Energy Research Centers, various locations	3,000	0	0	3,000	0
78-2-c	Low Btu fuel gas small industrial demonstration plants, site undetermined (A-E and long-lead procurement only)	6,000 1/	0	0	6,000	1/
77-1-d	Component development and integration facility, Butte, Montana	12,200 2/	2/	5,000	4,200	3,000
76-1-a	Clean boiler fuel demonstration plant, New Athens, Illinois	91,000	19,340	51,660	0	0 3/
76-1-b	High Btu synthetic pipeline gas demonstration plant	220,000	0	10,000	29,000	181,000
76-1-c	Low Btu fuel gas demonstration plant	150,000	0	7,300	36,000	106,700
76-1-d	Fluidized bed direct combustion demonstration plant	16,250 4/	0	0	2,000	4/
			$ 19,340	$ 73,960	$ 86,800	$290,700

1/ Preliminary estimate of capitalized project items for 2 plants is $52,000,000 for the Government's share only. In addition, conceptual designs and alternate designs included under Operating Expenses for FY 1978 are estimated at $4,000,000.

2/ $24,800,000 was funded from Operating Expenses through the Transition Quarter, and will be transferred to the project in FY 1977. Current total estimated cost is $37,000,000.

3/ Through the Transition Quarter, $41,000,000 was authorized and appropriated for this project. $19,340,000 has been obligated through the Transition Quarter. The resulting unobligated balance of $21,660,000 plus $30,000,000 new budget authority appropriated in FY 1977 results in total unobligated availability of $51,660,000. An additional authorization of $50,000,000 was included in the Conference Authorization Bill (H.R. 13350). The project is undergoing reevaluation because of lack of technical data to produce a process design and because of high technical risk. No new budget authority is requested in FY 1978.

4/ Estimated cost of capitalized project items is $162,000,000 for the Government's share only. In addition, conceptual designs and alternate designs included under Operating Expenses for FY 1978 are estimated at $6,000,000.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

EXPLANATION OF PROJECTS IN SECTION A

1. Project 78-2-a Analytical research, chemistry and coal carbonization laboratory, Pittsburgh Energy Research Center, Pennsylvania ..... $ 6,600

This project provides for the construction of a new laboratory and office facility at the Pittsburgh Energy Research Center to accommodate analytical research, chemistry and coal carbonization laboratory functions. The new facility will provide space for expanded program needs and to alleviate congestion and marginal working conditions within the existing plant. The four story structure will consist of 50,000 sq. ft. with full basement and fan lofts.

Details of Cost Estimate:

	Item Cost	Total Cost
a. Engineering design and inspection		$ 0 a/
b. Construction costs		5,330
(1) Improvements to land	$ 145	
(2) Building	5,140	
(3) Utilities	45	
c. Standard equipment		670
Subtotal		6,000
d. Contingency at 10% of above costs		600
Total Project Cost		$ 6,600

Total Project Funding Requirements:

	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 0 a/	$ 0	$ 6,600	$ 0	$6,600
Total Direct Project Funding	$ 0	$ 0	$ 6,600	$ 0	$6,600

b. Other Related Annual Funding Requirements

	Annual Estimates
(1) Facility Operating Costs	$ 200
Total Other Related Annual Funding Requirements	$ 200

a/ Design completed with FY 1975 operating funds of $400,000.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

2. Project 78-2-b Modifications and additions to Energy Research Centers, various locations ..... $ 3,000

Existing facilities at ERDA's Energy Research Centers have undergone some rehabilitation in FY 1977. Further funds are requested in order to complete projects initiated in FY 1977 which will provide a proper work setting conducive to the efficient handling of the research projects conducted at these sites.

Of the $3,000,000 FY 1978 request $2,000,000 is necessary to comply with the Occupational Safety and Health Act (OSHA) to minimize hazardous working conditions, potential fire losses, control of pollutants and in general attain and maintain the level of protection of property and personnel. The remaining $1,000,000 will be used for general plant improvement projects at the Energy Research Centers of Bartlesville, Grand Forks, Laramie, Morgantown and Pittsburgh. The projects include such items as elevators, heating systems, air conditioning, tunnels, roofs and other general improvement projects.

Details of Cost Estimate:

	Item Cost	Total Cost
a., Engineering, design and inspection at approximately 10% of construction costs		$ 200
b. Construction Costs		2,400
(1) Building and Modifications at all five sites	$ 2,000	
(2) Other	400	
Subtotal		2,600
c. Contingency at 15% of above costs		400
Total Project Cost		$ 3,000

Total Project Funding Requirement:
Not applicable.

3. Project 78-2-c Low Btu fuel gas small industrial demonstration plants, site undetermined (A-E and long-lead procurement only) ..... $ 6,000 b/

This project currently includes the design, construction and operation of two demonstration plants dedicated to individual industrial users of energy, such as kilns, glass manufacturers, etc. The scale of these facilities will be at least one-third the size of commercial facilities. Proposers are free, however, to select the process, plant location, plant size and the coal to be processed in exchange for cost sharing with the Government. Based on an evaluation of proposals received by ERDA, it is expected that plant sizes will be in the range of 200 to 500 tons per day of coal (equivalent to about 15 to 45 MWe). The capability of handling various types of high sulfur and agglomerating (caking) coals is of particular interest.

b/ Authorization for A-E design services and long-lead procurement only. The very preliminary estimate of the Federal Government's share of the plant and capital equipment costs to design and construct two facilities dedicated to small industrial users is $52,000,000. The balance of the TEC will be requested in subsequent years.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Details of Construction Project Cost Estimates:

The estimated obligations for A-E services and long-lead procurement in FY 1978 is $6,000,000. The very preliminary estimate of the Federal share of plant and capital equipment funding for two low-Btu fuel gas small industrial plants is $52,000,000. The estimate is based on proposals received from prospective contractors which are currently being evaluated by ERDA.

Total Project Funding Requirements:

Not applicable.

4. Project 77-1-d Component development and integration facility, Butte, Montana ..... $ 4,200 c/

Construction of the Component Development Integration Facility (CDIF) began in FY 1976 and will be completed in 1978. This facility is intended to pursue open cycle MHD component development with the purpose of improving the technology and of laying the groundwork for a pilot-scale generation plant. The facility is located in Butte, Montana, and covers approximately 50 acres of a 93 acre site. It consists of two test beds each capable of testing and evaluating MHD components of about 50 thermal megawatt size. The FY 1978 budget request will provide the installation of equipment into this facility.

Details of Cost Estimate:

	Item Cost	Total Cost
a. Engineering, design inspection, and construction management		$ 5,400
b. Construction costs		25,800
(1) Site development (grading, utility installation, railroad siding, office and warehouse buildings)	$ 2,980	
(2) Major construction		
(a) General facilities (piping, electrical, fuel oil system)	4,470	
(b) Coal system (coal supply building, coal process equipment)	3,783	
(c) Combustion air system (building, compressor, heaters)	3,783	
(d) Seed system (building and equipment)	920	
(e) Operation and service facilities (building and equipment)	1,150	
(f) Component test area (building and equipment)	4,930	
(g) Water supply and treatment (building and equipment)	3,784	
Subtotal		31,200
Contingency at 25% of unobligated cost		5,800
Total Details of Cost Estimate		$ 37,000

c/ $24,800,000 has been authorized and appropriated under Operating Expenses through the Transition Quarter, and will be transferred to the project. $6,700,000 has been included in the FY 1977 Conference Authorization Bill (H.R. 13350) and $5,000,000 has been appropriated in FY 1977.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Total Project Funding Requirements:

	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 24,800	$ 5,000	$ 4,200	$3,000	$37,000
(2) CP&D	0	0	0	0	0
(3) R&D Prerequisite to Construction	730	0	0	0	730
(4) Expense Funded Non-Facility Equipment	483	2,716	3,551	1,583[d/]	8,333
(5) Other Project Related Costs	0	0	0	0	0
Total Direct Project Funding	$ 26,013	$ 7,716	$ 7,751	$4,583	$46,063

5. Project 76-1-a Clean boiler fuel demonstration plant, New Athens, Illinois ..... $ 0

The lack of data needed to produce a process design for agglomerating coals has delayed the completion of Phase I effort. Based upon the current evaluation, the technology for hydrocarbonization with agglomerating coal is considered to be high risk and the projected economics of a full scale plant are marginal when compared with projected economics of other coal conversion processes. Until further data are obtained in pilot scale test bed research which would reduce the risk and lead to a technically sound process design, ERDA will not proceed with this project beyond the completion of the process design.

6. Project 76-1-b High Btu synthetic pipeline gas demonstration plant ..... 29,000 [e/]

The high-Btu synthetic pipeline gas demonstration plant support objectives of the Federal Non-Nuclear Energy Research and Development Act of 1974, P.L. 93-410, and is specifically directed to stimulate industrial production of pipeline gas from coal, and to demonstrate and transfer to industry technology for converting coal to pipeline gas. The development of alternative sources for pipeline gas is especially needed in view of increasing production shortfalls from natural well head sources.

This project comprises the concept development, design, construction and operation of a demonstration scale plant to validate the commercial viability of a process for converting coal to pipeline gas. The results anticipated are the demonstration of technical performance, and commercial (economic) feasibility of the coal conversion process. Plant capacities may involve up to 5,000 tons coal input and up to 80 million standard cubic feet daily pipeline gas output. The construction and operating costs will be shared equally by the Government and an industrial partner. The industrial partner has selected the process and will act as the prime design and release requests for fabrication of major equipment.

The estimated cost for A-E services including site survey studies is $10,000,000 in FY 1977. The preliminary estimate for the Government's share of plant and capital equipment costs for the demonstration plant is $220,000,000.

d/ Funds identified in this category are included under Operating Expenses. These are estimates of non-facility costs of engineering (including detail design), of fabrication and of integration directly associated with the first complete experimental test train articles.

e/ $25,000,000 was authorized through the Transition Quarter, and $10,000,000 has been appropriated in FY 1977 for plant design and related activities.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Details of Construction Project Cost Estimates:	Item Cost	Total Cost
a. Engineering, design and inspection		$ 26,700
b. Construction costs		149,300
(1) Improvements to land, including site preparation, fencing, roads, parking lots and railway system	$ 11,900	
(2) Buildings, including administration, service, maintenance, gate house, fire station, control buildings and laboratories	6,000	
(3) Special facilities including gasification, processing, storage and off gas treatment systems	125,400	
(4) Utilities, including water and electric power generation	6,000	
Subtotal		176,000
c. Contingency at 25% of above cost		44,000
Total Construction Project Cost		$220,000

Total Project Funding Requirements: f/	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 0	$10,000	$29,000	$181,000	$220,000
(2) CP&D	0	0	0	0	0
(3) R&D Prerequisite to Construction	0	9,520	10,000	4,000	23,520
(4) Expense Funded Equipment	0	0	0	0	0
(5) Other project related costs (start-up, training of personnel, operations)	0	0	0	118,000	118,000
Total Direct Project Funding	$ 0	$19,520	$39,000	$303,000	$361,520

b. Other Related Annual Funding Requirements

	Annual Estimates
(1) Facility Operating Costs	$ 24,000
(2) R&D Operating Expenses directly related in the facility	0
(3) Capital Equipment Not Related to Construction but related to R&D in the facility	0
(4) GPP or other construction related to R&D in the facility	0
(5) Other Costs	0
Total Other Related Annual Funding Requirements	$ 24,000

f/ Funds have not yet been fully appropriated for this program. Indicated amounts are estimated obligational authority required.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

7. Project 76-1-c Low Btu fuel gas demonstration plant ..... $ 36,000 g/

This project supports the objectives of the Federal Non-nuclear Energy R&D Act of 1974 (P.L. 93-410). It is specifically directed to industrial applications. The project includes the conceptual design, construction and operation of a demonstration facility which would reveal the economic and technical feasibility of converting coal to fuel gas for use by an industrial community, i.e., to serve the needs to a local supplier distributing fuel gas centrally to several large industrial users. The FY 1978 funding will allow detailed plant engineering design to start early in the year, and will support requests for fabrication of major equipment scheduled for release late in the year. The preliminary current dollar estimate of the Government's share of plant and capital equipment costs is $150,000,000.

Details of Construction Project Cost Estimates:	Item Cost	Total Cost
a. Engineering, design, and inspection		$ 34,000
b. Construction costs		86,000
(1) Improvements to land, including site preparation, fencing, roads, parking lots and railway system	$ 6,100	
(2) Buildings, including administration, service, maintenance, gate house, fire station, control buildings and laboratories	3,100	
(3) Special facilities including gasification, processing, storage and off gas treatment systems	73,800	
(4) Utilities, including water and electric power generation	3,000	
Subtotal		120,000
c. Contingency at 25% of above cost		30,000
Total Construction Project Cost		$ 150,000

Total Project Funding Requirements: h/	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 0	$ 7,300	$36,000	$106,700	$150,000
(2) CP&D	0	0	0	0	0
(3) R&D Prerequisite to Construction	0	10,800	35,200	3,100	49,100
(4) Expense Funded Equipment	0	0	0	0	0
(5) Other project related costs (start-up, training of personnel, operations)	0	0	0	6,200	6,200
Total Direct Project Funding	$ 0	$18,100	$71,200	$116,000	$205,300

g/ $18,750,000 was authorized through the Transition Quarter, and $7,300,000 has been appropriated in FY 1977 for plant design and related activities.
h/ Funds have not yet been fully appropriated for this program. Indicated amounts are estimated obligational authority required.

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

b. Other Related Annual Funding Requirements:

	Annual Estimates
(1) Facility Operating Costs	$ 3,400
(2) R&D Operating Expenses directly related in the facility	0
(3) Capital Equipment Not Related to Construction but related to R&D in the facility	0
(4) GPP or other construction related to R&D in the facility	0
(5) Other Costs	0
Total Other Related Annual Funding Requirements	$ 3,400

8. Project 76-1-d Fluidized bed direct combustion demonstration plant ..... $ 2,000 1/

This project provides for the design, construction and operation of an electric power generating plant that will directly combust high sulfur coal in an atmospheric fluidized-bed boiler. Fluidized-bed combustion is a direct combustion technique of raising steam to operate a conventional steam generating power plant. This technique has proven effective in removing over 90% of the pollutants; thereby greatly reducing or completely eliminating the need for further post-combustion gas treatment. This technology is also capable of burning high sulfur coal of all ranks and quality and holds the promise of process improvements in heat transfer characteristics of smaller and more compact plant boilers and increased thermal efficiencies. The proposed facility will be designed for a base-load central station application. The demonstration plant is expected to be sized to 1600 tons per day of coal and generate about 200 MWe by delivering superheated steam to a commercial (state-of-the-art) steam turbine-generator connected to a local power grid. FY 1978 funds will be dedicated to initiating engineering design, site selection/evaluation efforts and procurement of long-lead items of equipment.

Details of Construction Project Cost Estimates:

The estimated obligations for A-E services and long-lead procurement in FY 1978 is $2,000,000. The very preliminary estimate of the Federal share of plant and capital equipment funding for the plant is $162,000,000.

Total Project Funding Requirements:

Not applicable.

1/ Preliminary estimate of the Federal Government's plant and capital equipment costs to design and construct a 200 MWe demonstration plant is $162,000,000. Requested funds in FY 1978 are for A-E and long-lead procurement only. The balance of the TEC will be requested in subsequent years. A conceptual design will be undertaken in FY 1977 to establish a more definitive cost estimate.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

SECTION B - Obligations for Capital Equipment Not Related to Construction

Subprogram	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
1. Liquefaction	$ 0	$ 0	$ 0	$ 400
2. High-Btu Gasification	0	0	100	300
3. Low-Btu Gasification	0	0	0	500
4. Advanced Power Systems	0	0	0	200
5. Direct Combustion	0	0	0	200
6. Advanced Research and Supporting Technology	0	0	0	300
7. Demonstration Plants	0	0	0	0
8. Magnetohydrodynamics	0	0	0	500
9. Other Capital Equipment	0	0	150	0
	$ 0	$ 0	$ 250	$ 2,400

JUSTIFICATION

1. Liquefaction ..... $ 400

This request is primarily to permit the acquisition of general and standard laboratory and testing equipment. The acquisition of these items is essential to maintain the overall capability of the Liquefaction subprogram.

2. High-Btu Gasification ..... $ 300

Support for this subprogram will necessitate the acquisition of laboratory and test equipment. The amount requested for FY 1978 will be used primarily for standardized equipment in the High-Btu Gasification projects.

3. Low-Btu Gasification ..... $ 500

This request is to provide items of general equipment which are essential to support the Low-Btu Gasification subprogram at ERDA's Energy Research Centers.

4. Advanced Power Systems ..... $ 200

The amount requested for FY 1978 will be used for the general acquisition and replacement of laboratory and test equipment in connection with projects in the Advanced Power Systems subprogram at the National Laboratories.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
COAL PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

5. Direct Combustion ..... $ 200

General testing equipment and laboratory modifications are necessary to provide support for the Direct Combustion subprogram. These items are requested for FY 1978 in the amount of $200,000.

6. Advanced Research and Supporting Technology ..... $ 300

The Advanced Research and Supporting Technology subprogram has activities conducted at a number of the Energy Research Centers and National Laboratories. This request is for the acquisition of laboratory and test equipment in support of these activities.

7. Magnetohydrodynamics ..... $ 500

This request is for the acquisition of standard laboratory and testing equipment in order to provide support for the MHD subprogram.

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Operating Expenses
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM

PROGRAM STATEMENT

	B/A	Obs.	B/O
Estimate FY 1978.....	$ 71,100	$ 71,100	$ 63,000
Estimate FY 1977.....	42,887	46,300	36,387
Increase.....	$ 28,213	$ 24,800	$ 26,613

Petroleum and natural gas supply about three-fourths of the Nation's energy. These fluid fuels will continue to be the Nation's main energy source for many years. Recent estimates indicate that production of domestic petroleum and natural gas will drop rapidly in the late 1970's and 1980's without new sources or the stimulating techniques of enhanced oil recovery (EOR) and enhanced gas recovery (EGR).

Present extractive technology is grossly inefficient. Two-thirds of the oil discovered to date remains in the reservoir (about 300 billion barrels) not producible with current recovery practices and economics. The potential for EOR is in the area of 60 billion barrels of normal gravity oils and 28 billion barrels of heavy oils and bitumen. This potential constitutes the goal for EOR, which could extend the supply of domestically available oil resources by at least 10 critical years. A nearer term goal would be to increase significantly the production of normal gravity oils by 1985. The production by present EOR methods is about 240,000 barrels per day. ERDA-sponsored programs are designed to encourage and accelerate domestic production and are parallel and supplemental to oil industry efforts rather than competitive.

The need for improved oil recovery techniques has been recognized in the recently completed in-depth strategy analysis of enhanced oil recovery. This comprehensive study contained in the "Management Plan for Enhanced Oil Recovery" brought together available information in a logical documented framework of analysis and included direct surveys with 15 companies (6 majors, 3 intermediate and 6 independents). Based on current and projected industry EOR efforts a 600,000 B/D production from EOR has been estimated for 1985. If the budget request of $46,100,000 for FY 1798 is authorized and the projects begun are continued as programmed, the estimated incremental daily production in 1985 could be about 800,000 barrels

For each of the identified technical options in the Management Plan, there is some ERDA activity with one or more companies. The research efforts are not uniformly distributed, and are constrained by uncertainty and the long payout times. An EOR project is typically 4 to 8 years. Four processes show promise for recovering more oil from existing reservoirs, namely, micellar-polymer, carbon dioxide, improved waterfloods, and thermal (steam, and in situ combustion). A total of 23 field tests will be underway in FY 1977, 22 of which are pilot-size, and one demonstration size. These include 6 micellar-polymer, 5 carbon dioxide, 4 improved waterfloods and 7 thermal pilot-size tests, and one micellar-polymer economic pilot demonstration. The momentum of ongoing work and required background studies on some of the new initiatives restrict full implementation of the Management Plan in FY 1978. Rather, the budget year will be one of transition with some of the recommended projects being initiated in FY 1979 and beyond.

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

A logical progression from the laboratory to develop alternate technologies is to go first to field mini-tests involving a few wells (up to five), to a pilot test of 25 to 50 acres, to a commercial demonstration involving 200 or more acres. Pilot tests take 4 to 8 years generally and commercial demonstrations 10 or more years. The most significant data, however, are usually developed in the first 3 to 5 years. All of these technologies require fluid injection through porous media to either release oil and/or move it to production wells. A definition of required chemicals, equipment, and manpower is part of this job.

An integral part of an aggressive EOR program is to establish base-line data on all major U.S. reservoirs and to select the best candidates for the different EOR processes. This effort was initiated in FY 1976 and continues. This base line reservoir data then becomes part of a broader task of gathering, collating, and analyzing data coming from field tests of all varieties and finally performing inter-field analyses. This is part of the program that leads to technology transfer from ERDA to the oil industry. A particular need for this kind of technical assistance is for the small and medium-sized oil producers who do not have ready access to this kind of technology.

The mechanism for technology transfer derives from ERDA participation in all phases of the technology development. The final phases of development are the pilot and commercial field demonstrations, in which ERDA cost shares up to 50 percent with industry. This provides maximum flexibility and utilization. The in-house supporting research program must be all-inclusive with respect to developing fundamental data, laboratory and small pilot testing, and technical analysis of results.

Current proved natural gas reserves (228 trillion cubic feet) amount to about an eleven-year supply at the current consumption rate. These proved reserves are found in conventional reservoirs (high permeability sandstone and carbonate reservoirs) and can be easily produced and still provide a decent profit incentive for the gas producing companies.

There are currently four large unconventional gas resources of natural gas which are not being fully exploited:

1. the gas-bearing shales of the Eastern United States
2. the low permeability ("tight") sandstone gas reservoirs of the Rocky Mountain region
3. the free methane present in coal seams
4. the high-pressure, methane-saturated aquifers of the Gulf Coast Region (geopressured aquifers)

A comprehensive Enhanced Gas Recovery Program Strategy Document will be completed in FY 1978. This document will coordinate both planning and implementation of all ERDA activities and projects in Enhanced Gas Recovery. The basic concepts and format for this strategy document will be similar to the recently published Management Plan for Enhanced Oil Recovery (December 1976).

ERDA has initiated a multi-year project directed toward the stimulation of natural gas production in the three major Eastern U.S. petroliferous basins. The objective of the project is to stimulate increased commercial production of natural gas by providing reliable resource data, developing economic extraction alternatives, and demonstrating the commercial feasibility of promising production techniques. The project should provide a significant contribution to the domestic energy base, supply a clean fuel for Eastern industrial use, and help to alleviate anticipated near-term and long-term shortages of natural gas.

The ERDA Eastern Gas Shales project will be oriented specifically toward determining the true magnitude of potential gas reserves in the shale, thoroughly characterizing the shale, and evaluating and improving state-of-the-art gas exploration and extraction technology. Results will be continually evaluated to determine areas in which new or additional studies may be needed and the desirability of planning and conducting a more extensive research, development, and demonstration (RD&D) program. The project will concurrently monitor and protect the environment from possible damage resulting from natural-gas development activities.

ERDA emphasis is also being placed on the large resource of natural gas which is not being adequately exploited, that is, the low-permeability ("tight") sandstone gas reservoirs of the Rocky Mountain region (Western Gas Sands Project). The domestic oil and gas industry has made no real effort to exploit this resource due to technological problems and attendant uneconomic returns on their investment. Estimates of potentially recoverable gas reserves range from 600 to 1200 trillion cubic feet (Tcf). These reserves represent a potential 30 to 60 year supply of natural gas at the current national consumption rate of 20 trillion cubic feet a year.

These reserves figures are gross estimates based upon very limited geological and engineering data. The true magnitude of the recoverable reserves and a comprehensive assessment of the physical and chemical properties governing reservoir behavior have not been determined. Preliminary data developed by cost-shared (ERDA-industry) field tests of various stimulation and production techniques applied to these tight sandstone reservoirs are encouraging.

A "new initiatives" program (methane from coal and geopressured aquifers) will begin in FY 1798. Preliminary program planning and contractual studies to refine data on the resource bases and establish better economic assessments will be initiated. Close coordination will be maintained with projects in ERDA's Conservation and Geothermal Energy Divisions and with the Department of the Interior.

Two sources of natural gas are available to decrease the difference between supply and demand. Imports are one source; however this source can be unreliable--as was so dramatically demonstrated by the oil embargo in the winter of 1973-74 and the tripling of import gas prices by Canada. Gas from unconventional geologic sources is the only domestic source to augment supply. Neither of these sources will completely fill the supply gap. Vulnerability to the adverse effects associated with importing a large percent of our energy supply will be lessened by the development of technology to produce gas from these domestic sources.

A report from the National Research Council, Board of Mineral Resources Commission on the Natural Resources forum held in early 1976, states four unconventional geologic sources of natural gas. These sources include gas saturated geopressured aquifers, carbonaceous shales (Devonian), tight gas sands and coal seams. ERDA's current enhanced gas program is concentrated on gas from carboneaceous shales and tight gas sands.

There are an estimated 100 billion barrels of undiscovered petroleum resources available under the outer continental shelf. The considered opinion of the petroleum industry is that the best chance of discovering the most oil, fastest, is in these offshore areas. The hostile environments encountered in these frontier areas strain the state-of-the-art technology and impose the requirement for extensive RD&D activities. In order to complete the necessary RD&D with a compressed time schedule, and in this way accelerate the development of this vital resource base, it is important that ERDA plan an offshore technology RD&D program.

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

As part of its planning and evaluation effort, ERDA is appraising the current and projected state-of-the-art of offshore technology; is defining those R&D efforts required to accelerate needed technology; is identifying those R&D efforts appropriate to its mission, and will plan to determine the priorities of these efforts.

SUMMARY OF ESTIMATES BY SUBPROGRAM

Page No.	Subprogram	Actual FY 1976 B/A	Actual FY 1976 Obs.	Actual FY 1976 B/O	Actual TQ B/A	Actual TQ Obs.	Actual TQ B/O	Estimate FY 1977 B/A	Estimate FY 1977 Obs.	Estimate FY 1977 B/O	Revised Estimate FY 1978 B/A & Obs.	Revised Estimate FY 1978 B/O
93	1. Enhanced Oil Recovery ..	$25,700	$15,418	$13,935	$4,646	$16,016	$4,471	$23,782	$24,913	$21,682	$46,100	$40,100
96	2. Enhanced Gas Recovery ..	13,494	5,340	4,730	3,100	9,387	2,976	14,874	16,643	11,274	22,000	19,500
99	3. Drilling, Exploration & Offshore Technology ...	2,229	1,274	984	680	1,080	1,404	2,400	2,955	1,600	1,600	2,000
101	4. Processing and Utilization	1,797	1,822	1,849	450	470	489	1,831	1,789	1,831	1,400	1,400
	Total Petroleum and Natural Gas	$43,220	$23,854	$21,498	$8,876	$26,953	$9,340	$42,887	$46,300	$36,387	$71,100	$63,000

JUSTIFICATION OF SUBPROGRAMS

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
1. Enhanced Oil Recovery	B/A	$ 23,782	$ 46,100	+ $ 22,318
	B/O	21,682	40,100	+ 18,418

Objectives

The Enhanced Oil Recovery (EOR) subprogram objective is to encourage and support industry efforts to develop and demonstrate the technologies involved to increase production rates and percentage recoveries of original oil in place as described in the EOR Management Plan as follows:

1. Cost sharing field demonstrations to accelerate implementation of EOR technology.
2. Pursue concurrent in-house and contractor research and development supporting the field tests.
3. Provide a means for documentation and dissemination of developed data on EOR technology.
4. Maintain an aggressive research program in ERDA and industry laboratories and academic institutions on EOR to provide a basis for present and future recovery methods.

Accomplishments:

A major accomplishment was the recent completion of a stategy analysis which establishes, on a sound analytical base, ERDA's role in EOR. This analysis, contained in the "Management Plan for Enhanced Oil Recovery," examined what industry would accomplish without ERDA involvement, analyzed the impact of technical and non-technical Federal initiatives, and placed priorities on possible RD&D project areas, comprising a 5-year recommended program. The study includes an analysis of the effects of price and beneficial tax measures as an alternative to R&D programs.

ERDA has initiated 23 cost-sharing field contracts with industry that will test the feasibility of four EOR technologies in various types of domestic reservoirs. The funding for these projects is 35% ERDA and 65% industry. Based on the estimates of industry activity the ERDA cost-shared contracts represent about one-third of the industry EOR projects in these four categories. In micellar-polymer flood tests, for example, well over half the acreage under test is in projects sponsored by ERDA. Some of the 23 field tests underway in FY 1977 can already be credited with small additional oil production although the production response is normally delayed by approximately one year and most of the incremental production comes later in a project's lifetime. While it is too early to judge the results of the tests, all the projects have already generated higher quality geological and engineering data which are indispensable in designs of successful projects like these.

Budget Request:

The Enhanced Oil Recovery subprogram budget request for FY 1978 is $46,100,000, an increase of $22,318,000 over FY 1977. The increase is primarily to cover incremental funding of pilot and commercial field starts begun in FY 1977. Increases will be needed in FY 1978 as wells are completed and actual stimulation activities begin at the sites. In addition, the increased funding will provide for initiation of new projects that have the highest priority in the EOR Management Plan based on their potential for relatively near-term incremental increase in oil production.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
a. Micellar-Polymer Process	$ 7,500	$ 12,500	+ $ 5,000

Two pilot (the California and mid-continent projects) and one commercial demonstration (the Illinois project) field tests were initiated in FY 1976. One new pilot test in a reservoir having a low salinity will be initiated in FY 1977 to fill in the gap in a management matrix of untested reservoir variables for the design of micellar-polymer projects. These will require heavy incremental funding in FY 1978. In addition, the work being done to extend the application of the micellar-polymer process to California sandstone reservoirs will be increased.

b. Carbon Dioxide Flooding	$ 5,500	$ 6,600	+ $ 1,100

Three new projects were initiated in FY 1976. Supporting research specific to CO_2 flooding and an important engineering study of CO_2 separation and distribution will require incremental funding in FY 1978. In addition, two new projects will be initiated in FY 1978: one new project will help to develop and improve the carbon dioxide miscible process in carbonate reservoirs having a high residual oil saturation; and the other new project will develop an improved carbon dioxide miscible process for application in the Southwest and Montana carbonate reservoirs.

c. Improved Waterflooding	$ 1,000	$ 3,500	+ $ 2,500

The FY 1976 pilot test in the Wilmington Field (one of the largest in the United States) will require incremental funding in FY 1978 and the one new pilot start in FY 1977 will require some funding in FY 1978.

d. Thermal Recovery	$ 4,500	$ 12,000	+ $ 7,500

A FY 1977 Tar Sands RFP will require incremental funding of $2,000,000 in FY 1798. The EOR Management Plan indicates that the thermal recovery technology has the highest potential for relatively near-term increased production of petroleum. Therefore, six new projects will be initiated in FY 1978. One project will develop the technology to overcome emission problems in the

application of steam drive to shallow, heavy oil reservoirs. A second project will use cheaper fuels to generate steam in shallow, heavy oil reservoirs. A third project will improve the efficiency of the steam drive process in shallow, heavy oil reservoirs. A fourth project will use cheaper fuels for generating steam in light oil reservoirs. A fifth project will find alternate uses for heavy crude, and a sixth project will develop better well completion techniques and/or a downhole steam generator to produce heavy oil from deep reservoirs.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
Environmental Studies and Other Support	$ 5,282	$ 11,500	+ $ 6,218

In addition to environmental studies for specific processes described in preceding sections, other more general work is required and will be started. The bio-oxidation of organic matter in general, including crude oil and chemicals, is one approach among several. The handling and disposal of fluids containing hydrogen sulfide is another example. Basic research work to develop new ideas, promote advanced technology and support ongoing field activities will continue at BERC, MERC, LERC and SFOPM in enhanced oil recovery. This ongoing work supplements oil industry research efforts. Several large university projects are active in the micellar-polymer technology and would be continued in FY 1978. Also an increased effort will be expended to better define residual oil saturations. The budget request would provide for small field tests and associated applied research at BERC, LERC and MERC in FY 1978. Two new special projects will be initiated. One project will assess the value of early versus stepwise implementation of enhanced oil recovery processes in Prudhoe Bay reservoirs. The other project will ascertain if significant offshore abandonments will occur and ascertain preferred recovery techniques to defer their implementation.

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

		Estimate FY 1977	Revised Estimate FY 1978	Increase or Decrease
2. Enhanced Gas Recovery	B/A	$14,874	$22,000	+ $ 7,126
	B/O	11,274	19,500	+ 8,226

Objectives: The objectives of the Enhanced Gas Recovery subprogram are: (1) Provide an improved scientific basis for prompt, orderly development of the Nation's natural gas resource by conducting a thorough study of the Eastern gas shales aimed at determining the true magnitude of potential gas reserves in these shales and development of gas exploration and extraction technology for these phases, and by conducting a similar study and stimulation technology development for the tight sandstone gas reservoirs of the Rocky Mountain region; (2) Add 10 trillion cubic feet of natural gas to domestic proved reserves by 1985. These goals are to be met primarily through cost-sharing field projects with industry to develop stimulation technologies.

Stimulation technologies currently being pursued to increase production rates and increase gas reserves are:

Massive hydraulic fracturing.
Chemical explosive fracturing.
Directional drilling of wells to intersect a maximum number of fractured planes.

Support work necessary to implement and augment these field projects include:

Interagency and contract work with the USGS and state universities and state geological surveys to more definitively identify the resource base and reservoir characteristics.
ERC's and National Lab studies, experiments and reports to specify promising technologies, identify and solve problems in application of these technologies and to disseminate results to industry.
Other contract work as needed with industry to investigate specific problem areas.

Accomplishments

Accomplishments to date primarily have been in developing an understanding of problems associated with resource characterization and evaluation of target sources and with stimulation technology development. Problem areas identified are:

Conventional down-hole logging and testing techniques are not applicable to evaluating marginal gas formations.
Extent, direction, and inclination of hydraulically induced fractures are unknown.
Clean-out difficulties are encountered in chemical-explosive fractured wells.
Economics of directionally drilled wells are questionable.
Extremely limited data exist to define and characterize resource targets.

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

Initial work to attack the above problems includes:

Eastern Gas Shales Project planning is essentially complete--14 contracts issued.
Western Gas Sands Project planning was initiated.
Electro-potential method of fracture mapping appears promising. Other methods are being investigated.
Log interpretation techniques are being pursued.
Eight cost-share field tests with industry in massive hydraulic fracturing were initiated.
A new directionally drilled well cost-shared project has begun.
Three new chemical explosive fracturing cost-shared projects have been negotiated.

Budget Request

The FY 1978 budget request of $22,000,000 for Enhanced Gas Recovery is an increase of $7,126,000 over the request for FY 1977. The Enhanced Gas Recovery subprogram consists of four separate projects in FY 1978: the Eastern Gas Shales Project ($10,000,000), the Western Gas Sands Project ($10,000,000), Methane from Geopressured Aquifers ($1,500,000), and Methane from Coal ($500,000). The budget request will ensure continuation of the Eastern Gas Shales Project (Devonian shale) in FY 1978 at the level of about $10,000,000--$4,000,000 for massive hydraulic fracturing; $1,000,000 for chemical explosive fracturing; $300,000 for deviated wells; $4,000,000 for resource characterization; and $700,000 for environment and support. The budget request will also provide for a balanced program for the development of high priority projects addressing the considerable potential resources of the tight sandstone formations of the Western United States. The development of the Western Gas Sands is being guided by the relatively near-term benefits to be derived.

	Budget Authority		
	Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
a. Massive Hydraulic Fracturing	$ 6,030	$ 11,500	+ $ 5,470

Industry cost-shared field tests begun in FY 1976 and FY 1977 will be completed or continued under incremental funding along with support projects at the ERC's and National Labs. This includes four field projects to be continued in the Eastern Gas Shale Project (EGSP). The projects required are based on the number of parameters to be tested such as fluid time viscosity and flow rate. Other additional work is to consist of an expanded testing program at the Nevada Test Site and an accelerated program in rock mechanics and log interpretation.

b. Chemical Explosive Fracturing	$ 1,560	$ 1,500	- $ 60

Incremental funding of on-going cost-shared field tests and in-house support work account for about half of the requested funding. Additional work will consist of an expansion of a successful on-going project and a new chemical explosive technique

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FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

("tuned" explosives) will be investigated. These efforts relate to the Eastern Gas Shales Project as well as the Western Gas Sands Project. Production through natural fracture systems, difficulty in cleaning out heavy fluids from hydraulic fracturing and sensitivity to water must be evaluated.

	Budget Authority Estimate FY 1977	Rev. Est. FY 1978	Increase or Decrease
c. Deviated Wells	$ 300	$ 300	$ 0

Level funding will provide for a third well in this project. Results from the previous two wells drilled will be evaluated. These efforts are also related in part to EGSP and three or four field tests are needed to properly evaluate this technique.

d. Resource Characterization	$ 6,084	$ 7,000	+ $ 916

Resource Characterization work will continue at the planned level in the Eastern Gas Project. This work will account for about half of the requested funding. Additional work will be initiated on resource characterization of the tight sandstone gas reservoirs of the Rocky Mountain area as part of the Western Gas Sands Project and two additional sources of fuels with relatively near-term potential: methane from geopressured aquifers and methane from coal seams.

e. Environment and Support	$ 900	$ 1,700	+ $ 800

An environmental assessment for each major field project will be made to assure that no adverse environment effects are overlooked. Projects will be initiated as needed to solve specific environmental problems. Support work will continue to define and refine the Western Gas Sands Project.

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
3. Drilling, Exploration and Offshore Technology	B/A	$ 2,400	$ 1,600	- $ 800
	B/O	1,600	2,000	+ 400

Objectives

To expand and accelerate development of new domestic sources of oil and gas through cooperative development and demonstration of critical new technology needed:

for safe and reliable structures and operations in frontier areas (deep drilling, deep offshore and arctic);

for higher efficiency (faster, lower cost and lower risk operations) to bring marginal prospects within the range of economic feasibility;

to expeditiously satisfy leasing, inspection and regulatory requirements, socioeconomic impacts and ecological concerns, both real and imagined.

Accomplishments:

The drilling and exploration program initiated in FY 1976 produced important results which are being utilized in the search for oil and gas. Further, initial planning for an offshore technology program substantiated the need for this effort.

The joint industry/ERDA program to complete development and to demonstrate a system to measure and telemeter directional data from the bit while drilling was highly successful. The joint industry/ERDA project to demonstrate a downhole electric motor for improved efficiency in drilling was field tested. A study summarizing past work and analyzing the performance of the many types of drill motors provided guidance on research on downhole drilling motor systems; this has been highly useful to industry as well as ERDA. Studies of parameters affecting drilling performance in deep wells demonstrated the capability to make full size, stimulated deep well measurements in the laboratory under controlled conditions, and produced interesting results on the mechanics of rock failure under drilling conditions.

Work on attaching synthetic diamond cutting element produced a significantly stronger bond for this material. Solution of this problem will now allow further development and application of this type of cutting structure in drilling. Development engineering of improved drilling fluid instrumentation for field use in hot, deep drilling situations resulted in improvements to available instruments and prototypes of new instruments are being tested. Materials studies on steels and elastomers for hostile environments are progressing well. An important accomplishment in this area is the service rendered to industry through the availability of technical expertise developed and supported by the program.

Because of the urgent need to address offshore problems delaying exploratory drilling, work was initiated in FY 1977 and is already producing results. In this work, significant accomplishments were made toward developing seafloor instrumentation system for deployment, data acquisition and communication of measurements for seafloor stability and earthquake motions. This program is a unique cooperative effort of several agencies (ERDA, NOAA, and USGS), industry (Shell Oil and others) and the Sandia National Lab. This work will be terminated at the end of FY 1977.

Budget Request

The Drilling, Exploration and Offshore Technology subprogram request is $1,600,000 for FY 1978. The decrease in this subprogram reflects the termination of projects to develop and field test an advanced drilling system and efforts on improved seafloor instrumentation. Continuation of the cost-shared downhole telemetry system demonstration is included at a reduced level. FY 1978 funding for work on synthetic diamond bit cutters, improved drilling fluid instrumentation and severe service elastomers and steels is requested at the same level as FY 1977.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Drilling and Exploration	$ 1,800	$ 1,000	- $ 800

The drilling and exploration category is directed at the development of new drilling and exploration technology which will accelerate the recovery of oil and gas from all domestic sources.

In 1976, the petroleum industry spent over $3 billion on drilling alone in the U.S. Faster drilling, more efficient operations, safer methods, improved communications and technology transfer and more effective exploration could make these dollars go further. This would accomplish two important objectives--additional exploration and drilling will result in more discoveries of oil, and expanded drilling and exploration efforts will accelerate the availability of oil and gas, decreasing our dependence on imports.

b. Environmental and Advanced Concepts Support	$ 600	$ 600	$ 0

Industry has identified advanced technology needs for development of the frontier areas and has called for Government participation in assessments, feasibility studies and basic research. Added efforts are needed in such areas as: platform concepts, arctic transportation, seafloor power supply, subsea production systems, drilling and producing from tunnels.

The acquisition and analysis of offshore oil and gas engineering meteorological, oceanographic and environmental data are essential to conduct the planning, design, and systems implementation of projects to accelerate and enhance the availability of offshore oil and gas. These data will be analyzed to ascertain the technical, economic, and environmental feasibilities of oil and gas extraction in the offshore frontier areas. Identification of data needs and sources will continue at the FY 1977 level.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM - continued

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
4. Processing and Utilization	B/A	$ 1,831	$ 1,400	- $ 431
	B/O	1,831	1,400	- 431

Objectives:

The emphasis of this subprogram is on the characterization and processing of heavy petroleum fractions, asphalt utilization, crude oil identification, and fuels utilization. Limited work will also be done on characterization and processing of shale oil and coal liquids. Part of this effort will be under the supervision of the Division of Materials and Exploratory Research, particularly in the area of refining technology and novel exploratory processes. Part of the former crude oil identification and characterization work to the extent of $900,000 has been placed in EOR support.

Accomplishments:

At BERC the characterization and processing of heavy petroleum fractions from Kansas crudes will be concluded in FY 1977. At both BERC and LERC these specialized analytical techniques were extended to heavy oil from tar sands, coal liquids and shale oils. Under asphalt utilization, LERC has made much progress in correlating new analytical techniques to physical properties and applicability to road building. At BERC sophisticated new analytical methods have been used to finger print 40 crude oils for oil spill identification. Under fuels utilization at BERC two advanced-concept engines are being tested. Gasoline production from coal liquids was started.

Budget Request:

The budget request for budget authority in FY 1978 is $1,400,000, a decrease of $431,000 from FY 1977. The budget for this subprogram will provide for a continuation of basic research work. This subprogram will include some engine testing of re-refined lubricating oils and shale oil products.

Oil identification work relates to basic needs for assistance in oil spill and oil source identification and will become part of an oil field classification system. The characterization and processing of heavy oils has gone on for several years and is important for design of heavy oil and tar sand recovery projects. The work is being extended into shale oil and synthetic fuels.

A relatively small physical facility for engine testing of fuels and lubricants (including dynamometer testing) and the skilled engineers and scientists using it are necessary in the growing ERDA liquid fuels program. The effort in refining process technology and utilization of alternate fuels ties in with this activity and will be continued.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Plant and Capital Equipment
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
A. Obligations for Construction Projects	$ 0	$ 0	$ 0	$ 0
B. Obligations for Capital Equipment Not Related to Construction	100	9	360	600
Total Obligations for Plant and Capital Equipment	$ 100	$ 9	$ 360	$ 600

Obligations for the Petroleum and Natural Gas Program for FY 1978 are estimated at $600,000 of which:

$600,000 is for Capital Equipment Not Related to Construction justified in Section B below, requested for authorization in the proposed Authorization Bill.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
PETROLEUM AND NATURAL GAS PROGRAM: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

SECTION B - Obligations for Capital Equipment Not Related to Construction

Subprogram	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
1. Enhanced Oil Recovery	$ 100	$ 9	$ 190	$ 300
2. Enhanced Gas Recovery	0	0	0	300
3. Drilling, Exploration and Offshore Technology	0	0	0	0
4. Other Capital Equipment	0	0	170	0
Total Petroleum and Natural Gas Program	$ 100	$ 9	$ 360	$ 600

JUSTIFICATION

1. Enhanced Oil Recovery ..... $ 300

The capital equipment requirements for this subprogram are such items as stirred reactors, filters, pumps, chromatographs and test equipment for furnishing a laboratory to support enhanced oil recovery projects.

2. Enhanced Gas Recovery ..... $ 300

The capital equipment requirements for the enhanced gas recovery program are for Fischer assay equipment, imagery enhancement, photographic equipment, well log equipment, microscopes and other laboratory equipment.

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Operating Expenses
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM

PROGRAM STATEMENT

	B/A	Obs.	B/O
Estimate FY 1978.....	$ 39,000	$ 39,000	$ 33,500
Estimate FY 1977.....	30,514	35,740	20,059
Increase.....	$ 8,486	$ 3,260	$ 13,441

The Oil Shale and In Situ Technology program contains two major subprograms; Oil Shale and In Situ Coal Gasification. The technology for conventional mining and surface retorting of oil shale, has advanced to a level believed capable of early commercial application to richer grades of oil shale, averaging over 25 gallons per ton, although commercial-scale equipment and operations have not been demonstrated. Present ERDA strategy in this area consists of making its Anvil Points facility available for industry-sponsored projects, providing for the technology transfer of results through the ERDA observer program; providing general consultation to industry; conducting laboratory-scale supporting research on problems relevant to general oil shale processing, both above-ground and in situ, and contracting for development of promising advanced processing methods above the level of bench-scale research but less than commercial-feasibility demonstration scale.

The ERDA Oil Shale subprogram is focused mainly on developing technology capable of improving total resource recovery and lowering environmental impacts and water requirements. This is accomplished through development of various in situ extraction techniques capable of exploiting the leaner and deeper oil shale deposits as well as offering an alternative to present technology. In addition to the advantages of in situ methods of relatively smaller water, manpower, and shale disposal requirements, the potential application to lower grade shales is important in that most of the total estimated resource of 1.8 trillion barrels of shale oil in the Western Green River formation is in low-grade deposits that may never be recovered by techniques that involve conventional mining. Laboratory-scale research on new process technology includes fundamental research on methods potentially offering similar advantages for aboveground processing.

Eastern oil shales of Devonian and Mississippian age represent an additional, large, potential energy resource although their extent is presently poorly defined. These shales are potentially major producers of synthetic gas and oil although they are considered to be of lower grade than Western shale from an oil production standpoint. They are geologically similar to Western oil shales, and it is believed that similar technology can be used in exploiting these shales by in situ methods.

The present Oil Shale subprogram includes oil production research involving true in situ methods that require no mining; modified in situ methods that require partial mining; advanced processing technology with potential for reducing environmental impacts and improved energy efficiency of second-generation commercial plants; gas production research targeted to both Eastern and Western oil shales; environmental studies related to the in situ processes being developed; and supporting research for oil shale processing that is not tied to any specific technology but rather to oil shale development problems in general.

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

In situ conversion of oil shale to liquid and gaseous products offers several potential advantages over conventional mining and surface processing, both economic and environmental, although it is presently much less developed. However, no single version of in situ technology is applicable to the full range of oil shale deposit types. True in situ techniques requiring no mining to provide the required permeability for passage of gases and liquids are believed most suitable for relatively shallow deposits characteristic of the Eastern shales of Devonian and Mississippian age that range from Pennsylvania to Texas in a broad but poorly defined belt, and to some geologically similar but chemically different types of oil shale in Wyoming, Colorado and Utah. This technique is difficult and is not believed suitable for shales grading over 30 gallons per ton or at great depth, such as in the center of Colorado's Piceance Creek Basin, and is considered best applied to shale beds too thin or lean for economic mining. Modified techniques that require partial mining followed by massive rubblization are believed to offer the most promise especially for richer, deeper and thick shale deposits. However, it has not yet been established that very thick beds of rubblized shale can be successfully retorted, particularly if layers of rich shale are included. Four major variations of modified in situ retorting are of interest, with choice partially governed by actual thickness of oil shale to be processed. One of these is referred to as vertical modified, in which more or less square individual chambers are mined into which the overlying shale is broken to create an in-ground retort. A second is a horizontal modified technique.

Another modified technique is a variant of the horizontal technique applicable only to very shallow depths typical of some large areas of Utah deposits and involves significant surface disturbance although much less than the alternative of open pit mining, while a fourth technique involves use of void space created by dissolution of water-soluble salts as found in the Leached Zone of Colorado's Piceance Creek Basin.

The other major subprogram, In Situ Coal Gasification, has the objective of developing environmentally acceptable technology for the commercial production of fuels and energy from coal in place. The subprogram seeks to further enhance the utilization of the vast coal reserves of the United States which will supply much of our short and intermediate-term energy needs. More than 85 percent of our coal resources are unsuitable to be commercially exploited by conventional mining. In situ processing, especially gasification, provides a means to utilize these otherwise unuseable resources while providing benefits of minimal environmental disruptions, lower water usage and relief of mine safety problems and the shortage of skilled miners. If in situ processing can be controlled and run efficiently, the savings resulting from a smaller surface plant could permit a selling price for the gas which would be cheaper than entirely surface-based gasification processes.

The nature of the coal resource varies from region to region in thickness, dip, depth and composition. The program contains projects which use different technical approaches to exploit different resources. Proof of commercial feasibility will require both scaleup of process size and verification of the design performance at a number of sites. Process development is pursued by field tests and supported by laboratory and analytical studies directed toward understanding the process behavior in order to control it. Remote instrumentation will be developed to assure adequate process monitoring for control purposes. Environmental studies support each project to assure that impacts will be minimized.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT

OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

The expanded budget also supports exploratory laboratory and field work to evaluate processes which use Southwestern dry coals, Western or Gulf lignites, and thinner seam bituminous coal resources near use centers in the Midwest and East. Recent field tests have been very encouraging. The proposed funding increase will be used to accelerate the development and eventual commercialization of this promising technology.

SUMMARY OF ESTIMATES BY SUBPROGRAM

Page No.	Subprogram	Actual FY 1976			Actual TQ			Estimate FY 1977			Estimate FY 1978	
		B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
108	1. Oil Shale	$14,985	$ 7,780	$ 7,024	$2,250	$4,714	$2,486	$22,278	$27,020	$13,323	$28,000	$21,500
112	2. In Situ Coal Gasification	6,137	6,724	8,217	1,680	1,982	2,069	8,236	8,720	6,736	11,000	12,000
	Total Oil Shale and In Situ Technology ..	$21,122	$14,504	$15,241	$3,930	$6,696	$4,555	$30,514	$35,740	$20,059	$39,000	$33,500

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

JUSTIFICATION OF SUBPROGRAMS

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
1. Oil Shale	B/A	$ 22,278	$ 28,000	+ $ 5,722
	B/O	13,323	21,500	+ 8,177

Objectives:

The Oil Shale subprogram has both near-term (to 1985) and mid-term (1985-2000) objectives. The immediate objective is to support development of a commercial shale oil and gas industry with a daily capacity equivalent to at least 300,000 barrels per day by 1985. This objective will be fostered by providing the technology base for commercial implementation by 1980 through development and demonstration projects in cooperation with industry. The mid-term objective is to provide the technology base to expand an oil shale industry to its full potential by maximizing resource recovery efficiency and minimizing environmental impacts and water requirements through cooperative projects with industry, backed up by university and ERDA laboratory research as necessary.

Accomplishments:

Field research and demonstration program will be initiated under the cost sharing contracts addressing the in situ shale oil production techniques resulting from a Program Opportunity Notice (PON) issued in FY 1976. Of the five different potential in situ methodologies addressed by the PON, projects representing four of these were selected for contract negotiations. The first tasks to be completed under each of these projects will be the Environmental Impact Assessment and establishment of environmental monitoring and control programs. ERDA's in-house field testing program will include work at six test locations or field sites in Southwestern Wyoming and Eastern Utah related to both true and modified in situ technology development. Three experiments will be completed and five initiated involving fracturing or retorting. The oil production tests by direct combustion that began in April 1976 at ERDA's Rock Springs, Wyoming, Site 9 project will be completed and followed by secondary recovery testing with a hot fluid sweep with post-retorting evaluation also expected to be completed in FY 1977. The environmental monitoring and testing program at this site should continue at least into FY 1978. Field testing will also be initiated to assess alternative technologies for in situ fracturing and gasification of Devonian Shale, following completion and approval of environmental assessment requirements. This work is expected to be conducted under contract in the Antrim Devonian Shale of Michigan. Both ERDA's in-house and contract in situ projects will be supported by laboratory research and field instrumentation research by ERDA's National Laboratories and Laramie Energy Research Center. A study of water conservation with in situ oil shale development, jointly funded by ERDA and the U.S. Department of the Interior, will be completed. Additional monitoring-well, corehole and revegetation studies will be established in regions of known or expected in situ activity to conduct studies of effluents from shale processing. Research strategy documents describing environmental research requirements of the field tests program will be completed.

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

FY 1977 anticipated accomplishments include completion of a project on refining of shale oil by the Colorado School of Mines, coring and evaluation of several potential in situ sites to select locations for planned field tests at depths of 1000 feet in Utah and 1500 feet in Wyoming, and initiation of semicontinuous flow reactor bench-scale test in the ongoing study of the carbon monoxide/water reaction with shale. Other continuing research will include studies of oil shale yield data, mineralogy, properties and deposit characterization and correlation; studies of conversion of shale oil to fuel products by hydrogen processing; and monitoring and data processing of industrial research at ERDA's Anvil Points facility including retorting and environmental studies.

Budget Request:

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Shale Oil Production	$ 16,200	$ 21,055	+ $ 4,855

The FY 1978 budget request of $21,055,000, an increase of $4,855,000 over FY 1977, provides for the continuation of projects that were underway in FY 1977, both inhouse and contract. This request includes incremental funding of contracts for in situ technology procured under the PON plus field instrumentation and other work by ERDA laboratories in conjunction with these projects, university research directly related to in situ shale oil production, and continued service contracts in direct support of this component of ERDA's oil shale research.

The major thrust of ERDA s shale oil production program is the development of in situ technologies through contracts procured under the PON capable of exploiting each of the major geologic types of oil shales while lowering environmental impacts and water requirements. The major types of oil shales to be addressed in this program include: deeply buried shales such as occur in the lower zone of the Piceance Creek Basin in Colorado; shallow beds such as in the upper zone of the Piceance Basin in Utah and Colorado; variable depth thin beds such as occur in Wyoming; and deep leached shale beds in Colorado. Of the various processes being developed, no one process is applicable to all of these major resource types. Each process was selected because it appeared most applicable to a particular type of resource. No one process has a clear-cut advantage although the vertical modified in situ process is the most technically advanced and appears closest to economic commercialization. The budget estimate would provide incremental funding for the field test of the modified in situ process at a site near Debeque, Colorado which was initiated in FY 1977. The estimate also provides incremental funding for other technology development efforts in the other promising technologies.

The budget request also includes funding for research projects that will be ongoing in FY 1977 at ERDA's Laramie Energy Research Center (LERC), Sandia Laboratories (SL), Lawrence Livermore Laboratory (LLL), and Los Alamos Scientific Laboratory (LASL) in general support of in situ technology development other than those activities that are specifically associated with particular contract projects. This includes coordinated research by LERC, SL, and LASL in the inhouse field test program and

related laboratory research to develop and test predictive design capability for oil shale fracturing based on rock mechanics properties of the shale and interaction of these with detonation characteristics of specific types of explosives; and development and use of diagnostic techniques to monitor in situ rubblization and subsequent retorting to provide the data required to check and improve upon the computer-generated predictive models. Similar coordination exists between LERC and LLL in development of process control models for the in situ retorting phase; laboratory research and tests in large batch retorts under simulated in situ conditions, plus data from field tests, will provide the data on shale chemistry and retorting parameters required to develop these models.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
b. Shale Gas Production	$ 3,600	$ 3,850	+ $ 250

The fiscal year 1978 budget request of $3,850,000, an increase of $250,000 over FY 1977, provides for continuation of projects underway in FY 1977, including incremental funding of a contract for a technology assessment project in the Devonian Shale of Michigan. The request includes $3,346,000 for a Devonian Shale project initiated in late FY 1976 with incremental funding of $3,150,000 programmed for FY 1977. The request also includes $504,000 to maintain normal progress of the project to optimize control parameter to permit production of the most economic ratios of gas to oil from Green River Formation in situ oil shales. The Devonian Shale project is expected to be performed in the Antrim Shale of Michigan, by Dow Chemical Company and members of the Michigan Energy Resources Research Association including private industry, universities, and State agencies, with supportive services by the Laramie Energy Research Center and Sandia Laboratories. Technology assessment field tests of two alternative fracturing and gasification techniques are expected to require up to 4 years, with the first test to be concluded in FY 1978. The LERC gasification program request will permit completion of testing in a half-ton gasifier after which design of a multi-ton gasification facility will be completed and construction begun. The multi-ton facility will simulate in situ parameters using shale of larger particle size that more closely approximates rubble-size in a field retorting experiment.

c. Environmental	$ 1,168	$ 1,380	+ $ 212

The FY 1978 budget request of $1,380,000 is an increase of $212,000 over FY 1977. It provides for continuing normal progress on inhouse projects and environmental aspects of the contract field projects ongoing in FY 1977, plus related university research. Of this total request $750,000 is for maintaining normal progress on LERC's programs. The work will include continued development and application of environmental strategy, development of residual effects of the field projects performed inhouse plus cooperation with other government agencies and industry. Field work will include continued monitoring-well, corehole and revegetation studies in regions of known or expected in situ activity and onsite analyses of effluent samples to maintain real-time monitoring for specific contaminants. More detailed and specialized analyses will continue to be performed under service contracts by the University of Wyoming. Green River Basin black trona water utilization studies will be continued. The remaining $630,000 will be used for incremental funding of environmental studies as a part of the cost-shared PON contracts for in situ technology development and for environmental research projects by universities.

(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
d. Supporting Research	$ 1,310	$ 1,715	+ $ 405

The FY 1978 budget request of $1,715,000, an increase of $405,000 over FY 1977 provides for normal progress on projects ongoing at LERC in FY 1977 and the initiation of funding specifically available for university basic research projects on oil shale.

The FY 1978 budget request includes $195,000 for research in support of oil shale development by universities and/or other private institutions that cannot be funded within the normal context of the budget, although exceptions exist in the area of environmental research and research directly supportive of ERDA's in situ shale oil production research. This initiative proposes establishment of a fund to support research projects for oil shale by universities or other institutions not fundable under other specific mission-oriented budget categories.

An estimated $1,520,000 is included in the FY 1978 budget request to support ongoing projects at LERC. These projects include field fracturing and recovery process development, gasification of oil shale tests, process evaluation from oil shale product characteristics, and environmental studies.

		Estimate FY 1977	Estimate FY 1978	Increase or Decrease
2. In Situ Coal Gasification	B/A	$ 8,236	$ 11,000	+ $ 2,764
	B/O	6,736	12,000	+ 5,264

Objectives

The In Situ Coal Gasification subprogram provides alternative technology for making fuels and energy from coal while expanding the Nation's usable coal reserves. Both low Btu gas and medium Btu gas are potential products and the medium Btu gas could be upgraded to a synthetic natural gas by further surface processing. Successful in situ processes could add over a trillion tons of coal to the United States reserves. The in situ coal gasification subprogram has the objective of developing environmentally acceptable technology for the commercial production of fuels and energy from coal in place.

The subprogram must deal with a unique set of problems to meet its objectives. The coal can be prepared to only a limited extent so the process designs are constrained by the nature of the coal in place and its surroundings. As a consequence the subprogram is divided into categories containing processes which use different concepts and combinations of techniques that appear promising for different resources. The process designs are affected by coal rank, dip, thickness, depth, hydrology and permeability. The resources have different geographic locations, so the projects address the unique regional characteristics which are important to commercialization such as water supply, land use, market availability, and environmental impacts.

Accomplishments

The Linked Vertical Wells (LVW) process is being developed by the Laramie Energy Research Center (LERC), using reverse combustion and the natural permeability of the lower-ranked coal to establish and control the underground reaction zone. The Hanna 1 test at a site near Hanna, Wyoming, gave 6 months production of 126 Btu/SCF gas. Improved techniques increased gas quality to 172 Btu/SCF at an average production rate of 8.5 million SCF/day, equivalent to six megawatts of electrical power. The gas quality was maintained over a two month test period ending in August 1976. Process efficiency exceeded 80%.

The Packed Bed (PB) process is being developed by the Lawrence Livermore Laboratory (LLL) using a site at Hoe Creek, near Gillette, in the Powder River Basin, Wyoming. The concept uses chemical explosives to fracture the coal and to produce an underground packed bed reactor. The steam/oxygen gasification is controlled by controlling the bed permeability with the explosive pattern. The first field test of the process concept was initiated by a two-shot explosive fracture in FY 1976. A preliminary gasification with air was run at the start of FY 1977 to scope potential process problems. This test showed that a forward gasification could be run without an initial reverse combustion linking. Larger scale tests will be fielded starting in mid-FY 1977, including a multiple shot explosive fracture test and experiments with novel methods for directed explosive fracture.

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM: - continued

The Longwall Generator (LG) process is being developed by the Morgantown Energy Research Center (MERC) using directional drilling to develop an underground gasification manifold. The coal resource has low natural permeability and a high swelling index and is expected to be difficult to gasify. After an extended period of development of a site near Pricetown, West Virginia, in the Appalachian Region, a deviated well 2000 feet in length was drilled into the 6 foot thick seam at a depth of 850 feet. The well was turned to lie horizontally for 500 feet in the coal seam. The economic feasibility of this technique will be evaluated. A preliminary gasification test is being designed for fielding late in FY 1977.

The Steeply Dipping Bed (SDB) process uses the natural geometry of the coal resource for process advantage. Part of the gas manifold may be easily drilled into the coal, subsidence should not adversely affect mechanical components, and gravity assists the formation of a packed bed at the bottom of the coal seam as the gasification zone moves upward. The SDB project will be started as phase 1 in FY 1977 by soliciting competitive bids from industry to analyze the known technology and develop a process model, to provide a site for testing, and to develop a program plan for the field test phase.

The major direct impacts of in situ coal processing are expected to be effects on underground water quality, surface disruption by subsidence, and air emissions. Secondary impacts will be socioeconomic effects and water usage when processes are deployed in arid areas with low population densities.

Engineering and scientific research will continue to support the major projects, especially in studying the chemical and physical behavior of coal and its surroundings under simulated in situ conditions. In addition, laboratory and process analyses will be made of a two-stage gasification concept applicable to Southwest dry coals.

Budget Request:

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
a. Linked Vertical Wells/Medium Thick Seams	$ 3,100	$ 4,200	+ $ 1,100

The FY 1978 funding for the LVW Project is $4,200,000, an increase of $1,100,000 above the FY 1977 level. This support will allow the Hanna 4 field test to be executed, a pilot plant scaleup to be planned, and a minimodule testing procedure to be developed to prove that the process is applicable to other sites with similar coal and geology. The funds will also support in situ instrumentation development.

The Hanna 4 test will determine the process performance at greater borehole separations, especially regarding the width of coal reacted as the borehole length increases. Air requirements and linking behavior will be measured. Well separations up to 150 feet will be used. This will test the possibilities of running the process with less boreholes, a decided economic advantage.

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

The results of Hanna 4 will be analyzed to determine whether one or two more sub-pilot scale field tests are needed. These tests would involve the operation of more than one module (a repeated set of wells) at a time to test the efficiency of coal usage and subsidence effects at a larger scale. The results will provide design data for a subsequent pilot scale operation. Fielding of one or both of these tests as Hanna 5 could start in the latter part of FY 1978.

Increased industrial participation will be encouraged by seeking an industrial contractor to assist LERC in fielding and testing Hanna. The contractor would provide an industry viewpoint during the test, determining commercial strengths and weaknesses. Since the Hanna tests will still be at the process development unit scale, cost sharing would not be expected at this stage. The pilot phase of the LVW process development will not be initiated before FY 1979 but preliminary work toward an environmental impact statement will start in FY 1978.

An industrial partner for the pilot stage will be sought on a cost sharing basis. It is expected this will result in a site change. The hardware phase will begin in FY 1980 with a plant design and run through FY 1983. Tentative plans for the plant include process control, blending of the product of several modules and any gas cleanup which is unique to the in situ product. No utilization is planned although the gas could be used to test low Btu gas turbines developed elsewhere in Fossil Energy.

A minimodule test technique to prove the process is applicable to several sites will be developed to simulate a module from the commercial scale process. Site geology data would be used in a process model to predict gas quality, operating characteristics and process efficiency within a reasonable error band. The minimodule test would then be run to verify the predictions. The minimodule test would be developed in FY 1978 at the Hanna site. The test would be refined and tried at other sites in subsequent years.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
b. Packed Bed/Thick Seams	$ 2,500	$ 2,200	- $ 300

The proposed FY 1978 operating funds for the Packed Bed (PB) process are $2,200,000, a decrease of $300,000 from the FY 1977 level. The plans include a larger scale air gasification test in a shallow site using one of the fractured beds produced in FY 1977.

This air gasification test will provide process data for a subsequent steam-oxygen test to be fielded starting in late FY 1978 and run in FY 1979. Steam-oxygen gasification gives a medium-Btu gas. The first test will define operational problems with temperature control, ash slugging, plugging in the absence of the nitrogen sweep gas in air, and quality of the medium Btu gas. The test will also show problems of process control and coal utilization efficiency in explosively fractured beds.

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

Later tests will be run in deeper sites. Shallow testing is cheaper; hence it will be more cost effective to first test the concept in a shallow seam. Deep coal is a prime candidate for the PB process because it is abundant in thick seams of good quality in the West, it is not commercially mineable, the process thermodynamics are favored by higher pressures, and surface subsidence should be more uniform from greater depths.

An explosive fracture field test will be designed and executed to improve the capability of predicting permeability enhancement. The underground reactor is created using explosive charges whose placement is predicted by computer codes. These codes compute the permeability resulting from specific charge sizes, interactions and firing sequence. The effect of depth will be very important. Added tests would improve the fracture models and control of the underground reaction zone.

An industrial contractor will be solicited to help carry out the field tests and to provide an industrial viewpoint to guide the process development in the most favorable direction toward commercialization. Since the test scale is at the PDU level, cost sharing will not be expected until a pilot scale project is started.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
c. Longwall Generator/Thin Seams	$ 900	$ 1,200	+ $ 300

$1,200,000 in operating funds are requested for FY 1978. This is a $300,000 increase in funding over FY 1977, and will permit a preliminary gasification test at the Pricetown site. The added funds will provide for the execution and analysis of this preliminary test to determine the in situ gasification characteristics of the coal. The test will give data to support one of two process options to be tested in FY 1979 using the LG concept. These two options are: a broad front reverse pyrolysis followed by a forward gasification between the deviated wells (or one well plus a series of vertical holes), and/or a gasification from the deviated well along hydrofractured cracks from vertical wells. Borehole gasification would be a backup test option. The test preliminary will give badly needed data to appraise the effectiveness of these concepts or need for modifications for the effective gasification of highly swelling bituminous coals.

The laboratory simulation will continue with parametric testing in conjunction with process modeling to generate more process concepts for swelling coals, both in the Pittsburgh seam and the Interior Basin. Process models will be related to economic factors to evaluate the optimum direction for process development.

d. Steeply Dipping Beds	$ 400	$ 1,100	+ $ 700

The Steeply Dipping Beds (SDB) project will be started as Phase I in FY 1977 by soliciting competitive bids from industry to analyze the known technology and develop a process model, to provide a site for testing, and to develop a program plan for the field test phase.

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FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM - continued

FY 1978 operating funds amounting to $1,100,000 are requested to start fielding the first field test. This is an increase of $700,000 over FY 1977 needed to move into the field. The funds will be used to meet the base equipment needs, to characterize and develop the site and to install the underground manifolding and instrumentation.

The field test program (Phase II) will be started in mid-FY 1978 using the design developed in Phase I. Only air gasification will be considered. The fielding should be done and testing begun in FY 1979. The first test would verify the process model and demonstrate technology for slant drilling into the seam and linking across the bottom of the seam.

Phase II will end with a preliminary design of a pilot plant. The subsequent pilot scaleup phase would be carried out by cost-sharing with industry. It is believed that this process concept has a high probability of success.

	Budget Authority		
	Estimate FY 1977	Estimate FY 1978	Increase or Decrease
e. Environmental Support	$ 500	$ 1,200	+ $ 700

The FY 1978 request for operating funds in the Environmental Support category is $1,200,000, an increase of $700,000 over the FY 1977 level. This substantial increase reflects the increased number and size of the field tests and opportunities to get process environmental data.

Of the total budget, $1,100,000 will fund environmental studies in air, ground water and subsidence for the four major processes. The LVW project will monitor emissions in the gaseous product stream over the entire Hanna 4 test to evaluate the loadings as modules are brought on stream, gasified and shut down. An appraisal of control equipment needs will result. Hydrology and water quality wells, sampling and analysis for the four projects will be done. The PB process may show the greatest subsidence, and will require extensive monitoring. LLL will continue to improve their subsidence models. The remaining funds will support site assessments and background data, tar analyses and control and impact analyses. This will support both the major projects and new concepts introduced in FY 1977 and FY 1978.

f. Advanced Concepts and Supporting Research	$ 836	$ 1,100	+$ 264

The FY 1978 request for this category is $1,100,000, an increase of $264,000 over FY 1977. The funds will permit continued research support of the major projects of concepts which could apply to dry seams, thin seams and lignites, and of increased research in non-invasive instrumentation techniques.

The FY 1977 program includes small projects for gasifying dry coals, thin Eastern coals, and Texas lignite. These studies are planned to continue in FY 1978, concentrating on the reactivity and fluid transmission capabilities of the resource and the behavior of the rock overburden. Problems associated with thin seams in all three types of resources will be studied.

Supporting research would show increased activity, especially in instrumentation development, which promises economic payoff, and in research which will lead to better understanding and control of the underground processes.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Plant and Capital Equipment
(Dollars in thousands, except whole dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
A. Obligations for Construction Projects	$ 0	$ 0	$ 0	$ 0
B. Obligations for Capital Equipment Not Related to Construction	200	226	500	2,500
Total Obligations for Plant and Capital Equipment	$ 200	$ 226	$ 500	$ 2,500

Obligations for the Oil Shale and In Situ Technology Program for FY 1978 are estimated at $2,500,000 of which:

$2,500,000 is for Capital Equipment Not Related to Construction justified in Section B below, requested for authorization in the proposed Authorization Bill.

(Dollars in thousands, except where dollars in narrative material)

FOSSIL ENERGY DEVELOPMENT
OIL SHALE AND IN SITU TECHNOLOGY PROGRAM: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

SECTION B - Obligations for Capital Equipment Not Related to Construction

Subprogram	Actual FY 1976	Actual TQ	Estimate FY 1977	Estimate FY 1978
1. Oil Shale	$ 200	$ 226	$ 450	$ 900
2. In Situ Coal Gasification	0	0	0	1,600
3. Other Capital Equipment	0	0	50	0
Total Oil Shale and In Situ Technology	$ 200	$ 226	$ 500	$ 2,500

JUSTIFICATION

1. Oil Shale ..... $ 900

The equipment requested is to maintain the ongoing and planned projects relating to the in situ processing of oil shale conducted at the Laramie Energy Research Center (LERC), the Lawrence Livermore Laboratory (LLL), Sandia Laboratories (SL), and Los Alamos Scientific Laboratory (LASL). By technology category, the requirements are: Shale Oil Production - $745,000; Shale Gas Production - $50,000; Environmental - $20,000; Supporting Research - $85,000. By laboratory, estimated requirements are LERC - $355,000; LLL- $135,000; SL - $400,000; LASL - $10,000. The estimated requirements for LLL and SL are largely for refurbishment of field instrumentation trailers that are available from other ERDA programs, to permit field monitoring and instrumentation support to the in situ shale oil and gas production contract projects getting underway in FY 1977. The LASL request is to permit acquisition of minor items of standard laboratory and testing equipment. The LERC request includes laboratory and testing equipment such as spectrometers and other analytical equipment; general program support equipment such as calculators, typewriters, lathes; and field project equipment such as compressors, tanks, pumps, forklifts, etc.

2. In Situ Coal Gasification ..... $ 1,600

The capital obligations for FY 1978 are estimated at $1,600,000. These funds are needed to purchase reusable equipment for both field and laboratory tests. The funds do not cover equipment such as implanted instruments that are destroyed by the field tests.

The type of equipment required is surface based instruments, recorders, controllers, computer modules for data processing and process control, valves, logging tools, equipment modifications to field trailers, gas handling equipment such as compressors and liquid oxygen dewars, laboratory instruments for mechanical and chemical analyses of coal, coal tars, and combustion products, and unique tools for specialized equipment.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
(Dollars in Thousands)
SUMMARY TABLE BY ENERGY RESEARCH CENTERS: BUDGET AUTHORITY

Fossil Energy Development	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	Estimate FY 1978
Bartlesville Energy Research Center (BERC)				
Operating Expenses: Coal Program	$ 890	$ 220	$ 900	$ 660
Petroleum and Natural Gas Program	4,577	653	4,811	5,665
Oil Shale and In Situ Technology Program	0	0	0	0
Conservation Program	250	40	340	400
Environment and Safety Program	0	0	0	0
Physical Research Program	50	15	75	200
Total Operating Expenses, BERC	5,767	928	6,126	6,925
Full Time Permanent Employment	160	160	160	162
Grand Forks Energy Research Center (GFERC)				
Operating Expenses: Coal Program	1,477	710	2,288	3,450
Petroleum and Natural Gas Program	0	0	0	0
Oil Shale and In Situ Technology Program	0	0	0	0
Conservation Program	0	0	0	0
Environment and Safety Program	0	0	0	0
Physical Research Program	0	0	0	0
Total Operating Expenses, GFERC	1,477	710	2,288	3,450
Full Time Permanent Employment	45	45	46	47
Laramie Energy Research Center (LERC)				
Operating Expenses: Coal Program	0	0	0	0
Petroleum and Natural Gas Program	1,500	74	1,660	1,419
Oil Shale and In Situ Technology Program	5,915	1,122	6,838	9,325
Conservation Program	0	0	0	0
Environment and Safety Program	0	0	210	350
Physical Research Program	0	0	0	0
Total Operating Expenses, LERC	7,415	1,196	8,708	11,094
Full Time Permanent Employment	133	133	140	142

(Dollars in Thousands)

SUMMARY TABLE BY ENERGY RESEARCH CENTERS - continued

Fossil Energy Development - continued

	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	Estimate FY 1978
Morgantown Energy Research Center (MERC)				
Operating Expenses: Coal Program	$ 4,838	$ 1,867	$11,826	$14,162
Petroleum and Natural Gas Program	986	610	2,360	2,900
Oil Shale and In Situ Technology Program	1,000	250	1,000	1,450
Conservation Program	50	0	194	200
Environment and Safety Program	0	0	50	100
Physical Research Program	0	15	120	170
Total Operating Expenses, MERC	6,874	2,742	15,550	18,982
Full Time Permanent Employment	171	171	179	181
Pittsburgh Energy Research Center (PERC)				
Operating Expenses: Coal Program	14,963	3,403	22,311	17,981 1/
Petroleum and Natural Gas Program	0	0	0	0
Oil Shale and In Situ Technology Program	0	0	0	0
Conservation Program	0	0	0	0
Environment and Safety Program	0	0	0	0
Physical Research Program	0	0	0	0
Total Operating Expenses, PERC	14,963	3,403	22,311	17,981
Full Time Permanent Employment	294	299	299	302
Summary of Energy Research Centers				
Operating Expenses: Coal Program	22,168	6,200	37,325	36,253
Petroleum and Natural Gas Program	7,063	1,337	8,831	9,984
Oil Shale and In Situ Technology Program	6,915	1,372	7,838	10,775
Conservation Program	300	40	534	600
Environment and Safety Program	0	0	260	450
Physical Research Program	50	30	195	370
Total Operating Expenses, ERCs	36,496	8,979	54,983	58,432
Total Full Time Permanent Employment	803	801	824	834

1/ Excludes $6,530,000 for operation of the 10 ton-per-day Synthoil PDU at Bruceton, Pennsylvania, previously shown as part of the Pittsburgh ERC.

Role of the Energy Research Centers

The Energy Research Centers (ERCs) play an important role in achieving ERDA goals in fossil energy. They have demonstrated the ability to achieve solutions to specific research and development problems affecting the time table of major fossil energy systems development. In addition to the in-house research efforts at each center, their technical personnel have been instrumental in a supervisory and liaison function in the management of contract research work with universities and laboratories in every major area of the fossil energy development program. Although relatively small, the ERCs are staffed by highly skilled scientists, engineers and technicians with a long history of accomplishments in RD&D in the production and utilization of fossil fuels. The ERCs have produced new ideas, new data, and new processes to better utilize our fossil energy resources.

Operating Expenses for the ERCs are essentially all furnished by Fossil Energy Development and are included under the line item for each program in the FY 1978 Budget Estimates. In addition, a relatively few projects are conducted at the Centers for other ERDA programs. The full justification for these activities are explained in the relevant program sections of the Budget.

Bartlesville Energy Research Center

Budget Authority	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	FY 1978 Estimate	FY 1978 Increase or Decrease
Direct Appropriations - Operating Expenses					
Fossil Energy:					
Coal Program	$ 890	$ 220	$ 900	$ 660	-$ 240
Petroleum and Natural Gas Program	4,577	653	4,811	5,665	+ 854
Total Operating Expenses, Fossil Energy	5,467	873	5,711	6,325	+ 614
Other ERDA Programs:					
Conservation Program	250	40	340	400	+ 60
Physical Research Program	50	15	75	200	+ 125
Total Operating Expenses, Other ERDA Programs	300	55	415	600	+ 185
Total Direct Appropriations	5,767	928	6,126	6,925	+ 799
Reimbursements	386	97	230	242	+ 12
Full Time Permanent Employment	160	160	160	162	+ 2

Fossil Energy Development - Energy Research Centers - continued

Research at the Bartlesville Energy Research Center is focused primarily on the production, processing and utilization of petroleum and natural gas; a lesser effort is devoted to the characterization and use of liquid fuels manufactured from non-petroleum sources. The Center plays a major role in providing in-house support research and technical oversight for ERDA's field demonstration projects in enhanced recovery of oil. In FY 1978, an increasing emphasis will be placed on the enhanced recovery of petroleum and natural gas from presently known U. S. reserves. The center also conducts important research in the development of advanced techniques for developing and testing synthetic fuels derived from coal. The increase in contract management as well as in-house R&D activities will require two additional full-time personnel spaces for FY 1978.

Coal. Characterization studies of syncrudes from coal were initiated in FY 1976 to provide the bases for processes to upgrade these materials to finished fuels and chemical feedstocks. In FY 1978 research will continue to provide information on the properties and on the combustion and engine performance characteristics of liquid fuels derived from coal which are developed throughout the coal program.

Petroleum and Natural Gas. Research and development activities in the area of oil and gas extraction are centered on developing improved secondary and tertiary methods for the recovery of oil and gas. Field operations will be conducted in micellar polymer flooding and caustic flooding. The effectiveness of massive hydraulic fracturing and the use of chemical explosives to increase recovery of natural gas from tight formations are being investigated. Research studies will continue on the characterization of crude oil and its products and on improved processing methods.

Other Programs. In the Energy Conservation Program, BERC will continue to investigate the use of alcohol and other substitutes for petroleum as fuels for highway vehicles. In addition to test and evaluation, this effort includes operation of a technical and operational data bank on vehicular performance using alternative fuels. In the Physical Research Program, studies at BERC will obtain critical data on the thermodynamic properties of major compound types present in syncrude from coal, shale oil, and heavy ends of petroleum. Studies on key condensed-ring aromatic and hydrosubstituted compounds will form an adequate experimental base for broad-ranged correlating equations which are based on chemical structure. In addition to these other ERDA programs, it is estimated that an equivalent of about 12 man-years at the Center will be engaged in reimbursable work for other Federal agencies in FY 1978, primarily the Department of Transportation.

Grand Forks Energy Research Center

Budget Authority	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	FY 1978 Estimate	FY 1978 Increase or Decrease
Direct Appropriations - Operating Expenses					
Coal Program	$ 1,477	$ 710	$ 2,288	$ 3,450	+$ 1,162
Total Direct Appropriations	1,477	710	2,288	3,450	+ 1,162
Reimbursements	135	0	0	0	+ 0
Full Time Permanent Employment	45	45	46	47	+ 1

Fossil Energy Development - Energy Research Centers - continued

The Grand Forks Energy Research Center is concerned primarily with the near and mid-term technologies for the utilization of Western coals, including lignite and subbituminous coals, in an environmentally sound manner to alleviate urgent energy supply problems in the Western and mid-Western U.S. One additional full-time personnel space is requested for FY 1978 in order to accomplish the increased in-house research workload and contract management responsibilities.

Coal. Research and development activities are continuing in the special problem areas of coal liquefaction, gasification and combustion and in the control of pollution arising from utilization of the relatively abundant lower Btu value coals. In the CO-Steam project, the effect of mineral matter in lignite on liquefaction will be studied. The effect of reactor design and gas and slurry recycle on liquefaction will be studied and the needed reactor component design undertaken. In the fixed-bed slagging gasifier, it is anticipated that a detailed investigation of liquid effluents will be started. The development of this data affects the design of scaled-up systems and is extremely important for environmental considerations.

Laramie Energy Research Center

Budget Authority	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	FY 1978 Estimate	FY 1978 Increase or Decrease
Direct Appropriations-Operating Expenses					
Fossil Energy:					
Petroleum and Natural Gas Program	$ 1,500	$ 74	$ 1,660	$ 1,419	-$ 241
Oil Shale and In Situ Technology Program	5,915	1,122	6,838	9,325	+ 2,487
Total Operating Expenses Fossil Energy	7,415	1,196	8,498	10,744	+ 2,246
Other ERDA programs:					
Environment and Safety Program	0	0	210	350	+ 140
Total Operating Expenses,Other ERDA Programs	0	0	210	350	+ 140
Total Direct Appropriations	7,415	1,196	8,708	11,094	+ 2,386
Reimbursements	61	15	60	20	- 40
Full Time Permanent Employment	133	133	140	142	+ 2

The Laramie Energy Research Center serves as the focal point for research and development on the production and utilization of vast oil-shale resources. Additionally, research is conducted in the fields of production, processing and utilization of petroleum and natural gas and in the in situ gasification of coal. An increase of two full-time personnel spaces is requested for FY 1978 in order to provide for the increases in program workload at the Center.

(Dollars in thousands, except whole dollars in narrative material)

Fossil Energy Development - Energy Research Centers - continued

Petroleum and Natural Gas. In FY 1978, the principal petroleum and gas area of research will be aimed at the development of processes for recovering oil from tar sand deposits, characterization of heavy liquids derived from fossil fuels, and methods for improving the performance and utilization of asphalts.

Oil Shale and In Situ Technology. A major effort is underway to develop an underground coal gasification process. The field test site is located near Hanna, Wyoming in a seam of sub-bituminous coal 30 feet thick at a depth of about 400 feet. In FY 1978, the main program thrust will be the development and demonstration of the modular concept for expanding underground coal gasification technology to a commercial scale.

In Oil Shale, current emphasis is being placed on the development of an in situ retorting process for recovering oil from oil shale deposits. Process support and field studies focus on developing fracturing techniques and methods for recovering oil from the fractured shale, and on refining the shale oil.

Other Programs. Environment and safety research activities will also be part of the LERC effort in FY 1978. A project which is jointly managed with the Fossil Energy activities is designed to identify environmental control needs for effluents from in-situ coal gasification systems. Data will be obtained from an in-situ environmental burn at the Hanna site, and an analysis of environmental control needs will be made. In addition, an equivalent of about one man-year of reimbursable project work primarily for Federal agencies other than ERDA is estimated for FY 1978.

Morgantown Energy Research Center

Budget Authority	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	FY 1978 Estimate	FY 1978 Increase or Decrease
Direct Appropriations - Operating Expenses					
Fossil Energy:					
Coal Program	$ 4,838	$ 1,867	$11,826	$14,162	+$ 2,336
Petroleum and Natural Gas Program	986	610	2,360	2,900	+ 540
Oil Shale and In Situ Technology Program	1,000	250	1,000	1,450	+ 450
Total Operating Expenses Fossil Energy	6,824	2,727	15,186	18,512	+ 3,326
Other ERDA Programs:					
Conservation Program	50	0	194	200	+ 6
Environment and Safety Program	0	0	50	100	+ 50
Physical Research Program	0	15	120	170	+ 50
Total Operating Expenses, Other ERDA Programs	50	15	364	470	+ 106
Total Direct Appropriations	6,874	2,742	15,550	18,982	+ 3,432
Full Time Permanent Employment	171	171	179	181	+ 2

Fossil Energy Development - Energy Research Centers - continued

Research and development on coal comprise the major activity at the Morgantown Energy Research Center. A diverse program is carried out to develop technology for direct combustion of coal and for converting it into clean-burning gases and oils. Enhanced recovery of oil and gas is also being investigated as is in situ gasification of coal. Two additional full-time personnel spaces are requested for FY 1978 to meet the increased in-house and contract management workload.

Coal. Current studies are aimed at the modification and operation of a fixed-bed coal gasifier and an accelerated hot gas clean-up effort at the pilot plant scale. Construction of the atmospheric fluidized-bed component test and integration unit which was begun in FY 1977 will continue. In Direct Combustion, fouling and corrosion of fireside surfaces are being studied.

Petroleum and Natural Gas. In FY 1978, characterization and resource inventory of U. S. natural gas reserves will continue with areas in Illinois, Michigan and the Appalachian region being emphasized. Results of FY 1977 studies will be analyzed for major impact on needed recovery technology. Additionally, the Center provides technical oversight for ERDA field demonstration projects on enhanced oil and gas recovery. These activities will be continued at about the same level in FY 1978.

Oil Shale and In Situ Technology. Program objectives are to demonstrate new technology, including directionally deviated wells that can be combined to degasify, devolatilize, carbonize and gasify relatively thin, deep Eastern coal seams. In FY 1978, laboratory studies will be continued, long wall generator flow testing will be completed, and techniques for reverse-burn and forward burn will be initiated.

Other Programs. An ongoing Conservation Program project at MERC to identify ways of recovering and utilizing the methane gas which is normally vented to the atmosphere during coal mining operations will continue in FY 1978. An Environment and Safety Program study will characterize and predict the potentially pathogenic effluents which could result from increased direct combustion and combustion of coal gasification products. There are proposed two Physical Research Program research projects for MERC in FY 1978. One would determine the chemical reaction mechanism, kinetics and catalyst activity during the hydrodesulfurization and hydrodenitrogenation of model coal derived compounds. The effect on the chemical reaction mechanism of these reactions proceeding simultaneously is also being investigated. The other study would be conducted on the dynamics of the attraction and capture of magnetic particles by magnetized fibers. The objective is to develop a theoretical understanding of the capture process sufficient to aid design and operation of practical separation devices.

Pittsburgh Energy Research Center

Budget Authority	Actual FY 1976	Actual Transition Quarter	Estimate FY 1977	FY 1978 Estimate	FY 1978 Increase or Decrease
Direct Appropriations-Operating Expenses					
Fossil Energy:					
Coal Program	$14,963	$ 3,403	$22,311	$17,981[a/]	- $4,330
Total Direct Appropriation	14,963	3,403	22,311	17,981	- 4,330
Full Time Permanent Employment	294	299	299	302	+ 3

a/ Excludes $5,630,000 for operations of the 10 tons per day synthoil PDU at Bruceton, Pa., previously shown as part of the PERC.

(Dollars in thousands, except whole dollars in narrative material)

Fossil Energy Development - Energy Research Centers - continued

The Pittsburgh Energy Research Center is the largest Federal laboratory devoted solely to research and development on coal. The Center carries out a diversified program on coal including: basic research to obtain new knowledge of the chemical and physical properties and reactions of coal; conversion of coal to electricity and to clean-burning liquid and gaseous fuels; and the environmental impact arising from coal usage. In order to accomplish the increased in-house research and program management responsibilities at the Center, three additional full-time personnel spaces are requested for FY 1978.

Coal. Major efforts are underway in the development of processes to gasify and to liquefy coal. Back-up research and technical direction is provided for the Synthane coal gasification pilot plant. A 10 ton-per-day Synthoil process development unit has been constructed to conduct operational tests on converting coal to low-sulfur fuel oil. In FY 1978, PERC will demonstrate process reliability, develop improved components and obtain process design data for the scale up of the synthoil process. In the coal hydroliquefaction process using disposable catalysts, improved catalyst blends will be developed. Other major projects will be in the research and development of technology in the Synthane process and in other advanced research and supporting technology.

In addition to the Energy Research Centers, the San Francisco Office of Program Management will undertake major Fossil Energy contract management responsibilities in FY 1978. The main objective of research at this facility is the development of new methods of stimulating oil production from California reservoirs. Methods being investigated for stimulating oil production include: cyclic injection of solvents, solvent steam injection and solvent micellar polymer waterflood. These activities will be continued in FY 1978 as will providing technical oversight to ERDA field demonstrations of enhanced oil and gas recovery.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
TRUST FUNDS
CONTRIBUTED FUNDS

Program and Financing (In Thousands of Dollars)

Identification code: 89-8575-0-7-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by activities:				
Direct program:				
1. Fossil energy development (b) Petroleum, natural gas, and oil shale	$ 76	$ 10	$ 40	$ 20
Total program costs	76	10	40	20
Change in selected resources (undelivered orders)	4	12	0	0
10.00 Total obligations	80	22	40	20
Financing:				
21.00 Unobligated balance available, start of period	-4	-12	0	0
24.00 Unobligated balance available, end of period	12	0	0	0
60.00 Budget authority (permanent)	$ 88	$ 10	$ 40	$ 20

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
TRUST FUNDS
CONTRIBUTED FUNDS

Program and Financing (In Thousands of dollars)

Identification code: 89-8575-0-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Relation of obligations to outlays:				
71. Obligations incurred, net	$ 80	$ 22	$ 40	$ 20
72. Obligated balance, start of period	15	20	32	32
74. Obligated balance, end of period	-20	-32	-32	-32
90. Outlays	75	10	40	20

TRUST FUND

ADVANCES FOR COOPERATIVE WORK

CONTRIBUTED FUNDS

Petroleum, natural gas, and oil shale - contributed funds

Funds contributed by states, counties, municipalities, and private sources are used to conduct research and investigations to promote the conservation, evaluation, and development of energy resources. Activities include composition and characterization of petroleum, engine testing of petroleum fuels, and oil shale development.

Estimates of advances to be used for these purposes are $20,000 for fiscal year 1977 and $20,000 for fiscal year 1978.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

SPECIAL FOREIGN CURRENCY PROGRAM

Program and Financing (In Thousands of dollars)

Identification code: 89-0104-0-1-305	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Program by Activities:				
Fossil Energy (program costs, funded)	$ 0	$ 2	$ 1,900	$ 2,200
Change in selected resources (undelivered orders)	1	0	4,747	-2,200
10. Total obligations	1	2	6,647	0
Financing:				
21. Unobligated balance, start of period	0	-6,649	-6,647	0
24. Unobligated balance, end of period	6,649	6,647	0	0
40. Budget authority (appropriations)	6,650	0	0	0
Relation of Obligations to outlays:				
71. Obligations incurred, net	1	2	6,647	0
72. Obligated balance, start of period	0	1	1	4,748
74. Obligated balance, end of period	-1	-1	-4,748	-2,548
90. Outlays	$ 0	$ 2	$ 1,900	$ 2,200

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U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1978 Budget Estimates
Appropriation - Special Foreign Currency Program
(Dollars in thousands, except whole dollars in narrative material)

SUMMARY TABLE BY SUBPROGRAM

Operating Expenses	FY 1976 Actual			TQ Actual			FY 1977 Estimate			Revised FY 1978 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O
Coal											
1. Extraction/Hydrogenation of Coal.	$ 5,350	$ 1	$ 0	$ 0	$ 2	$ 2	$ 0	$ 5,347	$ 1,700	$ 0	$ 2,000
2. Production of Clean Gas for Use in MHD Power Systems	1,300	0	0	0	0	0	0	1,300	200	0	200
Total Coal Program	$ 6,650	$ 1	$ 0	$ 0	$ 2	$ 2	$ 0	$ 6,647	1,900	$ 0	$ 2,200

PROGRAM STATEMENT

Estimate FY 1978	$ 2,200
Estimate FY 1977	1,900
Increase	$ 300

The Energy Research and Development Administration (ERDA) requested funding in the FY 1976 budget to support a three year program for selected research on extractive hydrogenation of coal, as well as a laboratory study to gasify coal for use in an MHD channel. Payment for these projects will be made in currencies of those nations in which the research projects are taking place, and which the U. S. Treasury determines to be in excess of our Nation's normal requirements. The programs described above will take place in the Republic of Poland. No new budget authority is requested for FY 1978. The estimated costs for the budget year are $2,200,000.

Poland has a large and growing coal industry, with extensive reserves but only small amounts of oil and gas. This has led to a strong research program to develop the needed technology for the conversion of coal to liquids and gases, as over 15 percent of Poland's energy requirements are furnished by imported oil and gas. No nuclear power stations have been installed.

Work on liquefaction of coal in Poland was started in 1966 and within four years a 5 kilogram (11 pounds) per hour development unit was operational. During a subsequent testing program, 15 types of coals have been studied. The specific goal of this program will be to utilize through international cooperation the technological expertise developed by Polish Government specialists in the area of coal conversion and coupling of magnetohydrodynamics (MHD) to coal gasification. Such activities will tend to corroborate or complement similar research activities conducted by ERDA.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL FUEL AND RELATED PROGRAMS
OBJECT CLASSIFICATION (In Thousands of Dollars)

Identification code: 89-0100-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Personnel compensation:				
11.1 Permanent positions	$ 12,989	$ 3,767	$ 14,774	$ 15,414
11.3 Positions other than permanent	2,890	840	2,120	3,576
11.5 Other personnel compensation	130	35	135	140
Total personnel compensation	16,009	4,642	17,029	19,130
Personnel benefits:				
12.1 Civilian	1,565	455	1,670	1,900
21.0 Travel and transportation of persons	724	152	945	1,702
25.0 Other services	238,950	104,166	479,036	626,018
Total costs, funded	257,248	109,415	498,680	648,750
94.0 Change in selected resources	99,498	51,149	147,539	125,050
Total direct obligations	356,746	160,564	646,219	773,800

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OPERATING EXPENSES
FOSSIL FUEL AND RELATED PROGRAMS
OBJECT CLASSIFICATION (In Thousands of Dollars)

Identification code: 89-0100-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
Reimbursable obligations:				
Personnel compensation:				
11.1 Permanent positions	$ 582	$ 70	$ 290	$ 262
Personnel benefits:				
12.1 Civilian	55	6	30	25
21.0 Travel and transportation of persons	15	2	10	10
25.0 Other services	229	26	265	308
Total costs, funded	881	104	595	605
94.0 Change in selected resources	57	3	0	0
Total reimbursable obligations	938	107	595	605
99.0 Total obligations	$ 357,684	$ 160,671	$ 646,814	$ 774,405

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PLANT AND CAPITAL EQUIPMENT

FOSSIL FUEL AND RELATED PROGRAMS

OBJECT CLASSIFICATION (In Thousands of Dollars)

Identification code: 89-0103-0-1-999	FY 1976 Actual	Transition Quarter Actual	FY 1977 Estimate	Revised FY 1978 Estimate
31.0 Equipment	$ 247	$ 255	$ 1,740	$ 4,670
32.0 Lands and structures	3,875	818	21,700	34,800
Total cost, funded	4,122	1,073	23,440	39,470
94.0 Change in selected resources	11,188	3,945	60,717	54,500
99.0 Total obligations	$ 15,310	$ 5,018	$ 84,157	$93,970

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

FY 1978 Budget Estimates
Permanent Positions
End of Year Ceilings

Fossil Energy Development	FY 1976	FY 1977	FY 1978
Direct Employment - Energy Research Centers			
Coal Program	494	510	511
Petroleum and Natural Gas Program	196	201	202
In Situ Technology Program	105	108	108
Total Direct Fossil Energy Development	795	819	821
Reimbursable Work	36	15	13
Total Full-time Employment - Energy Research Centers	831	834	834

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Los Alamos Scientific Laboratory
University of California
Albuquerque Operations Office

Conservation Research and Development
Electric Energy Systems and Energy Storage

1. Title and Location of Project: High bay addition, Los Alamos Scientific Laboratory, New Mexico

2. Project No. 78-1-a

3. Date A-E Work Initiated: 2nd Quarter FY 1978

3a. Date Physical Construction Starts: 1st Quarter FY 1979

4. Date Construction Ends: 1st Quarter FY 1980

5. Previous Cost Estimate:
Date: $ None

6. Current Cost Estimate
Date: 12/76 $800,000

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Obligations	Costs
1978	$ 800	$ 800	$ 200
1979	0	0	450
1980	0	0	150

8. Brief Physical Description of Project

This project provides for construction and equipping a single-story addition to an existing building required to support research and development activities associated with the superconducting power transmission program at Los Alamos.

The new addition approximately 67 feet long by 66 feet wide, will be constructed at Building SM-32, located in the main LASL technical area. It will have a total gross area of approximately 4,400 square feet, approximately 3,200 square feet of which will be high bay (30 feet). The new facility will be constructed with slab on grade and will provide space for operations (high bay), a screen room, a compressor room and a refrigeration room. As presently conceived, the facility will be a steel frame, prefabricated insulated metal building and will be fully sprinklered.

Improvements to land will include removal of existing paving for foundation work, grading, repairs to paved areas and some drainage diversion. Utilities will include sanitary sewer, water, natural gas, and electrical feeder and a new 750 kVA substation. Standard equipment will consist of laboratory furniture and fixtures.

78-1-a High bay addition, Los Alamos Scientific Laboratory, New Mexico — Electric Energy Systems and Energy Storage

9. Purpose, Justification of Need for and Scope of Project

This project will provide the space and services needed to support research and development associated with the superconducting power transmission program at Los Alamos.

In 1973, a significant new project, the Superconducting Power Transmission Line (SPTL) was begun in the LASL Low Temperature Physics and Engineering Group (Group Q-26). Initial staffing for this project came primarily from within the group, and their laboratory space plus consolidation of some other projects provided minimal space necessary to support program initiation. Later, additional Q-26 space became available when a large project funded by another Headquarters division was moved to a new location at LASL. Normal program and staff expansion during FY 1974 utilized this space. During FY 1975, expansion was accomplished only at the expense of overcrowding in existing office space and eliminating certain support activities being carried out by Q-26. By FY 1979-1980 the staff size is expected to be about double that of the present.

The proposed addition is essential in order to alleviate existing overcrowding as well as provide the facilities that are necessary to accomplish program goals.

A special high bay laboratory is needed both to develop hardware and components for Superconducting Power Transmission Lines (SPTL) and to house and test the prototype designs. The objectives of the high bay, high voltage laboratory are to perform tests on the prototype 100 kV DC SPTL, to perform developmental tests on short samples of 300 kV DC SPTL and to test SPTL prototypes up to 300 kV. Additionally, it is likely that utility acceptance tests of a DC SPTL can be performed in this laboratory.

Developmental tests on short samples of the 100 kV cable will be performed in an existing laboratory. The required stored energy of the impulse generator to test a 200- to 300-m long prototype 100 kV cable will be two or three times higher than that of the present impulse generator. The basic needs of housing such high energy equipment require a high-voltage, high bay area. Tests on 300 kV SPTL will be performed in the high bay facility after the work on the 100 kV cable is complete.

78-1-a High bay addition, Los Alamos Scientific Laboratory, New Mexico — Electric Energy Systems and Energy Storage

9. Purpose, Justification of Need for and Scope of Project (Continued)

The new facility will be designed for maximum economy in construction costs consistent with program requirement and compatible with sound engineering practices, all applicable ERDA Manual Chapters and Appendices, economy in operations and maintenance costs, and the life expectancy of the structure.

The gross annual cost (maintenance, janitorial services and utility charges) for operating the new facility will be approximately $15,000. The total annual cost of research and development program to be carried out in the new facility will be approximately $900,000, and the incremental program cost will be approximately $350,000.

10. Details of Construction Project Cost Estimates:

	Item Cost	Total Cost
a. Engineering, design and inspection at 15% of Construction costs, Item b		$ 75
b. Construction costs		500
(1) Improvements to land including grading, site preparation and drainage diversion	$ 10	
(2) Buildings, Energy Transmission Laboratory - 4,400 sq. ft. at $58.00	255	
(3) Special facilities including installation of on-hand equipment	75	
(4) Utilities including sanitary sewer, natural gas and electrical	160	
c. Standard Equipment		100
Subtotal		675
d. Contingencies at 18% of above cost		125
Total Construction Project Cost		$ 800

NOTE: The above estimates are based on conceptual design and feasibility studies that are approximately 60% complete.

11. Total Project Funding Requirements:

N/A

12. Method of Performance:

Design and inspection will be performed under a negotiated architect-engineer contract. To the extent feasible, construction and procurement will be accomplished by fixed price contracts and subcontracts awarded on the basis of competitive bidding.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Chicago Operations Office — Fossil Energy Development, Coal Program

1. Title and Location of Project: Analytical research, chemistry and coal carbonization laboratory, Pittsburgh Energy Research Center, Pennsylvania
2. Project No. 78-2-a
3. Date A-E Initiated: 2nd Qtr., FY 1975 1/
3a. Date Physical Construction Starts: 1st Qtr., FY 1978
4. Date Construction Ends: 4th Qtr., FY 1979
5. Previous Cost Estimate: Date: None
6. Current Cost Estimate: Date: 12/76 $6,600,000

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Obligation	Cost
FY 1978	$ 6,600	$ 6,600	$ 1,300
FY 1979	0	0	5,300

8. Brief Physical Description of Project:

The project provides for the construction of a new laboratory and office facility at the Pittsburgh Energy Research Center to accomodate analytical research, chemistry and coal carbonization laboratory functions. The new facility will provide space for expanded program needs and to alleviate congestion and marginal working conditions within the existing plant.

The proposed structure will be a multi-storied unit containing about 50,000 sq. ft. gross floor area and will be constructed within a courtyard adjacent to other PERC buildings. This location, in close proximity to other related laboratory management and service functions, will optimize not only the efficiency of operations but also available land area use in a restricted site. As presently designed, the proposed building is a four-story structure approximately 100 feet long and 100 feet wide and has a full basement and fan lofts.

The structure will consist of a reinforced concrete frame with reinforced concrete floor slabs. The roof will be built-up tar and gravel. Exterior walls will be compatible in appearance with adjacent masonry structures. Windows will be minimal in area and have insulating glass in fixed sash. Building insulation will be established by detailed cost benefit analysis as established by energy conservation criteria. This building will use and demonstrate solar heat technology to the maximum extent possible.

Vertical transportation will include a combination passenger and freight elevator and enclosed stairwells designed to resist fire for at least two hours. Each floor will have a main corridor extending from the office area at one end of the building to offices at the other end. The laboratories will be located off of the main corridor with separate entry halls. The separate entry halls actually serve the purpose of dividing other facilities such as stairwells and the elevator. Utility chases will be located on the outside walls of the laboratories (east and west walls).

1/ A-E initiated with FY 1975 Operating Expense funds appropriated to Office of Coal Research.

Interior partitions will be concrete block with painted finish, doors and frames will be hollow metal, ceilings will be suspended acoustic tile and resilient tile will cover floors (except where cast vinyl floors are required). Laboratory furniture will be metal and hoods will be provided where required.

Where possible, required services will be extended from adjacent facilities. The structure will be air conditioned throughout except for mechanical equipment areas. An outside cooling tower will be required. Various laboratory services will include: hot and cold water, distilled water, compressed air, natural gas, lighting, oxygen, nitrogen, various synthesis gasses, drainage systems, and electrical power and ground systems. Emergency electrial power will be obtained from a motor generator. Other building systems will include fire detection and suppression, paging and telephones. Steam for heating will be obtained from the site system. Ventilation systems will be based upon established safe practices for the protection of personnel whenever hazardous materials or toxic fumes are encountered.

9. Purpose, Justification of Need for and Scope of Project:
This facility is to house the expanding needs for space of analytical research, chemistry and coal carbonization laboratory at the Pittsburgh Energy Research Center. The added overall space will allow for increased efficiencies of present functions now being conducted under unsafe working conditions due primarily to the overcrowding. The resultant benefits will extend through not only the specific laboratories noted but to many of the other functions performed in present facilities.

The necessity of providing the laboratories, offices and other direct support space and equipment at the earliest practicable date is essential to program progress and any delay in providing the needed facilities will impact on related energy research progress. Early completion of the proposed addition will also permit increased efficiencies in organizational relationship and functions of other laboratory groups in an indirect manner.

Other research sections at the Pittsburgh Energy Research Center to be housed in safer and more efficient facilities as an indirect result of the proposed construction include the following:

Exploratory Engineering
Process Engineering
Energy Conservation
Chemistry
Spectro-Physics
Refining Technology
Environment and Conservation

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

78-2-a Analytical research, chemistry and coal carbonization laboratory
Pittsburgh Energy Research Center, Pennsylvania — Coal Program

10. Details of Construction Project Cost Estimate:

	Item Cost	Total Cost
a. Engineering design and inspection		$ 0 a/
b. Construction costs		5,330
(1) Improvements to land	$ 145	
(2) Building	5,140	
(3) Utilities	45	
c. Standard equipment		670
Subtotal		6,000
d. Contingency at 10% of above costs		600
Total Construction Project Cost		$ 6,600

11. Total Project Funding Requirements:

	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 0 a/	$ 0	$ 6,600	$ 0	$6,600
Total Direct Project Funding	$ 0	$ 0	$ 6,600	$ 0	$6,600

b. Other Related Annual Funding Requirements

	Annual Estimates
(1) Facility Operating Costs	$ 200
Total Other Related Annual Funding Requirements	$ 200

12. Method of Performance:
To the extent feasible, construction and procurement will be accomplished by fixed price contracts and subcontracts awarded on the basis of competitive bids.

a/ Design completed with FY 1975 operating funds of $400,000.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Headquarters — Fossil Energy Development, Coal Program

1. Title and Location of Project: Modifications and additions to Energy Research Centers, various locations
2. Project No. 78-2-b
3. Date A-E Work Initiated: 1st Qtr., 1978
3a. Date Physical Construction Starts: 3rd Qtr., FY 1978
4. Date Construction Ends: 4th Qtr., FY 1980
5. Previous Cost Estimate: Date: None
6. Current Cost Estimate: Date: 12/76 $3,000,000

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Obligation	Cost
FY 1978	$ 3,000	$ 3,000	$ 1,000
FY 1979	0	0	2,000

8. Brief Physical Description of Project:
This project provides for a variety of modifications required at the five Energy Research Centers (ERC) located in Bartlesville, Oklahoma; Grand Forks, North Dakota; Laramie, Wyoming; Morgantown, West Virginia; and Pittsburgh, Pennsylvania. Included are those modifications necessary to comply with the requirements of the Occupational Safety and Health Act (OSHA) of 1970, or are required to minimize potential fire losses; improve monitoring and control of pollutants entering the environment as required by the Federal Water Pollution Control Act; and in general to attain and maintain the level of protection of personnel, property and the environment consistent with Federal and ERDA policies and requirements.

Preliminary surveys completed to date indicate that sprinkler systems and improvements in ventilation will be required at all five locations to provide for safe working conditions. Required OSHA corrections include modifications to working areas and passageways, material handling and storage facilities and gas equipment, operating machinery to provide protective guards and other personal protection equipment.

Also included in order to maintain satisfactory and economical operating conditions and to accommodate new program development and changes in programs are a number of minor capital construction items as required. These items include building insulation, modification of power distribution systems, installation of research equipment, shop modification, air conditioner maintenance, building repairs and modifications, parking lot paving, roofing, painting of equipment, compressors, heating systems and boiler maintenance, lighting changes, equipment storage and other minor needs. Priority will be given to completing fire and safety work.

9. Purpose, Justification of Need for, and Scope of Project:
These projects will permit necessary modifications at the ERC's to upgrade the facilities to a level consistent with ERDA's existing guidelines for fire safety, compliance with OSHA regulations and standards and reduction of environmental pollution from onsite operations. In addition, ERDA's Energy Research Centers are in need of rehabilitation of existing facilities to provide a proper work setting conducive to the efficient handling of the research projects conducted at the sites.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

78-2-b Modifications and additions to Energy Research Centers, various locations — Coal Program

10. Details of Construction Project Cost Estimate:	Item Cost	Total Cost
a. Engineering, design and inspection at approximately 10% of construction costs ...		$ 200
b. Construction Costs		2,400
(1) Building and Modifications at all five sites	$ 2,000	
(2) Other	400	
Subtotal		2,600
c. Contingency at 15% of above costs		400
Total Construction Project Cost		$ 3,000

11. Total Project Funding Requirement:
Not applicable.

12. Method of Performance:
Design will be on the basis of negotiated fixed fee A-E contracts. To the greatest extent possible construction and procurements will be accomplished by fixed price contracts awarded on the basis of competitive bids.

Construction Project Date Sheet
(Dollars in thousands, except whole dollars in narrative material)

Headquarters — Fossil Energy Development, Coal Program

1. Title and Location of Project: Low Btu fuel gas small industrial demonstration plants, site undetermined (A-E and long-lead procurement only)
2. Project No. 78-2-c
3. Date A-E Work Initiated: 1st Qtr., FY 1978
3a. Date Physical Construction Starts: a/
4. Date Construction Ends: a/
5. Previous Cost Estimate: Date: None
6. Current Cost Estimate Date: 2/77 $6,000,000

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Appropriation	Obligations	Costs
1978	$ 6,000	$ 6,000	$ 6,000	$ 1,000
1979	0	0	0	5,000

8. Brief Physical Description of Project:
This project currently includes the design, construction, and operation of two demonstration plants dedicated to individual industrial users of energy, such as kilns, glass manufacturers, etc. The scale of these facilities will be at least one-third the size of commercial facilities, however proposers are free to select the process, plant location, plant size and the coal to be processed in exchange for cost sharing with the Government. Based on an evaluation of proposals received by ERDA, it is expected that plant sizes will be in the range of 200 to 500 tons per day of coal (equivalent to about 15 to 45 MWe).

The capability of handling various types of high sulfur and agglomerating (caking) coals is of particular interest.

FY 1978 funding will support conceptual and detail plant design and procurement of long-lead items of equipment. The very preliminary estimate of the Federal share of Plant and Capital Equipment funding for two low-Btu fuel gas plants, dedicated to small industrial users, is $52,000,000.

9. Purpose, Justification of Need for, and Scope of Project:
As outlined in the Federal Non-Nuclear Energy Research and Development Act of 1974, the production of clean fuel gas in support of manufacturing can be used to broaden the national energy base and promote our future independence from excessively large requirements for foreign oil. In addition, as a result of environmental regulation, many industrial companies which have previously used high sulfur coal have been forced to switch to clean coals and petroleum products which are in scarce supply. The economic production and utilization of processes which convert coal into clean burning fuel gas (a low-Btu gas with a heat content of between 150 and 500 Btu/ft^3) would reverse this trend. Industrial companies could then utilize sulfur coals in environmentally acceptable ways.

a/ Authorization for A-E design services and long-lead procurement only. The very preliminary estimate of the Federal Government's share of Plant and Capital Equipment cost to design and construct two facilities dedicated to small industrial users is $52,000,000. The balance of the TEC will be requested in subsequent years.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

78-2-c Low-Btu fuel gas small industrial demonstration plants, site undetermined (A-E and long-lead procurement only) — Coal Program

10. Details of Construction Project Cost Estimates:
The estimated obligations for A-E services and long-lead procurement in FY 1978 is $6,000,000. The very preliminary estimate of the Federal share of plant and capital equipment for two low-Btu fuel gas plants in $52,000,000. The estimate is based on proposals received from prospective contractors which are currently being evaluated by ERDA.

11. Total Project Funding Requirements:
Not Applicable.

12. Method of Performance:
The project will be conducted in three Phases:

Phase I	Conceptual Design and Plant Design
Phase II	Plant Construction
Phase III	Plant Operation

Phase I will be accomplished at Government expense. Phases II and III will be cost shared 50/50 with an industry partner.

To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bids.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Headquarters

Fossil Energy Development
Coal Program

1. Title and Location of Project: High Btu synthetic pipeline gas demonstration plant, site undetermined

2. Project No. 76-1-b

3. Date A-E Work Initiated: 3rd Qtr., FY 1977

3a. Date Physical Construction Starts: 4th Qtr., FY 1978

4. Date Construction Ends: 3rd Qtr., FY 1981

5. Previous Cost Estimate:
Date: 12/75 $25,000,000 a/

6. Current Cost Estimate:
Date: 12/76 $220,000,000 b/

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Appropriation	Obligations	Costs
1976	$ 20,000	$ 0	$ 0	$ 0
T.Q.	5,000	0	0	0
1977	0	10,000	10,000	2,000
1978	195,000	29,000	29,000	10,000
1979	0	75,000	75,000	80,000
1980	0	94,000	94,000	90,000
1981	0	12,000	12,000	30,000
1982	0	0	0	8,000

8. Brief Physical Description of Project:
This project comprises the concept development, design, construction and operation of a demonstration scale pipeline gas plant to validate the commercial viability of a concept for converting coal to pipeline gas. The results anticipated in this project are the demonstration of technical performance, and commercial (economic) feasibility of the coal conversion process. Plant capacities are expected to involve conversion of up to 4,000 tons per day coal input into 60 million standard cubic feet per day of pipeline gas. The construction and operating costs will be shared equally by the Government and industrial partner. The industrial partner has selected the process to be exploited as part of his proposal package for evaluation and acceptance. The industrial partner will act as the prime contractor for the design, construction and operation of the plant. A subcontractor will provide him engineering services. The FY 1978 funds are to initiate plant design and preliminary efforts for site selection, procurement of long-lead items of equipment and construction.

9. Purpose, Justification of Need for, and Scope of Project:
This project supports objectives of the Federal Non-Nuclear Energy Research and Development Act of 1974, P.L. 93-410, and is specifically directed to stimulate industrial production of pipeline gas from coal, and demonstrate and transfer to industry commercial scale technology for converting coal to pipeline gas. The development of alternative sources for pipeline gas is especially needed in view of increasing production shortfalls from natural wellhead sources.

a/ A-E and long-lead procurement only.

b/ Reported data are based on engineering design & construction cost estimates submitted by Conoco Coal Development Company (the proposed contractor selected to enter into negotiation with the Government to design, construct and operate this facility). This data is currently being reviewed by ERDA.

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Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

76-1-b High Btu synthetic pipeline gas demonstration plant, site undetermined — Coal Program

10. Details of Construction Project Cost Estimates:	Item Cost	Total Cost
a. Engineering, design and inspection		$ 26,700
b. Construction costs		149,300
(1) Improvements to land, including site preparation, fencing, roads, parking lots and railway system	$ 11,900	
(2) Buildings, including administration, service, maintenance, gate house, fire station, control buildings and laboratories	6,000	
(3) Special facilities including gasification, processing, storage and off gas treatment systems	125,400	
(4) Utilities, including water and electric power generation	6,000	
Subtotal		176,000
c. Contingency at 25% of above cost		44,000
Total Construction Project Cost		$220,000

11. Total Project Funding Requirements: a/

a. Direct Project Funding	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
(1) Construction Project	$ 0	$ 10,000	$ 29,000	$181,000	$220,000
(2) CP&D	0	0	0	0	0
(3) R&D Prerequisite to Construction	0	9,520	10,000	4,000	23,520
(4) Expense Funded Equipment	0	0	0	0	0
(5) Other project related costs (start-up, training of personnel, operations)	0	0	0	118,000	118,000
Total Direct Project Funding	$ 0	$ 19,520	$ 39,000	$303,000	$361,520

b. Other Related Annual Funding Requirements	Annual Estimates
(1) Facility Operating Costs	$ 24,000
(2) R&D Operating Expenses directly related in the facility	0
(3) Capital Equipment Not Related to Construction but related to R&D in the facility	0
(4) GPP or other construction related to R&D in the facility	0
(5) Other Costs	0
Total Other Related Annual Funding Requirements	$ 24,000

a/ Funds have not yet been fully appropriated for this program. Indicated amounts are estimated obligational authority required.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

76-1-b High Btu synthetic pipeline gas demonstration plant, site undetermined — Coal Program

12. Method of Performance:
This project is estimated to cover a period of eight years and will be conducted in three phases:

Phase I	Conceptual Design and Plant Design (20 months)
Phase II	Plant Construction (34 months)
Phase III	Plant Operation (42 months)

Phase I will be accomplished at Government expense. It is planned that Phases II and III will be cost shared 50/50 with an industry partner.

To the extent feasible, construction and procurements will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bids.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Headquarters

Fossil Energy Development
Coal Program

1. Title and Location of Project: Low Btu fuel gas demonstration plant
2. Project No. 76-1-c
3. Date A-E Work Initiated: 1st Qtr., FY 1978
3a. Date Physical Construction Starts: 4th Qtr., FY 1978
4. Date Construction Ends: 2nd Qtr., FY 1981
5. Previous Cost Estimate: Date: 12/75 $18,750,000[a/]
6. Current Cost Estimate: [b/] Date: 12/76 $150,000,000

7. Financial Schedule of Construction Project Funding:

Fiscal Year	Authorization	Appropriation	Obligations	Costs
1976 & T.Q.	$ 18,750	$ 0	$ 0	$ 0
1977	$ 0	$ 7,300	$ 7,300	$ 1,500
1978	131,250	36,000	36,000	14,000
1979	0	50,000	50,000	40,000
1980	0	40,000	40,000	60,000
1981	0	16,700	16,700	25,000
1982	0	0	0	9,500

8. Brief Physical Description of Project:
This plant comprises developing the design concept, constructing, and operating a demonstration plant furnishing clean fuel gas dedicated to an industrial site (it could serve the needs of a centrally located fuel gas distributor in supplying several large industrial users). The size of the plant is expected to range between 500-2000 tons of coal per day. The objective of the plant demonstration is to confirm the process economics and commercial feasibility of the fuel gas process selected. An industrial partner will be chosen for this demonstration, based in part on the economic promise of the process he selects. The project would utilize second generation gasifier technology. The industrial partner will be responsible for design, site selection, construction and operation as the prime contractor, and will share equally the costs of construction and operation with the Government. The FY 1978 funds are to support plant design efforts, long lead procurement commitments for capital equipment and to initiate plant construction.

9. Purpose, Justification of Need for, and Scope of Project:
The project supports the objectives of the Federal Non-Nuclear Energy Research and Development Act of 1974, P. L. 93-410, and is specifically directed to industrial consumers. Fuel gas (low-Btu gas) contains heat content of 150 to 500 Btu's per cubic ft. As a result of environmental regulations, many industrial companies which have previously used high sulfur coal have been forced to switch to clean coals and petroleum products which are in scarce supply. The production of clean fuel gas is a means by which those fuel resources, otherwise unavailable, can be used to broaden the national energy base, and promote national energy "independence".

a/ A-E and long-lead procurement only.
b/ Data are engineering design and construction costs based on proposals received from prospective contractors. These data are currently being evaluated by ERDA.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

76-1-c Low Btu fuel gas demonstration plant,

Coal Program

10. Details of Construction Project Cost Estimates:	Item Cost	Total Cost
a. Engineering, design, and inspection		$ 34,000
b. Construction costs		86,000
(1) Improvements to land, including site preparation, fencing, roads, parking lots and railway system	$ 6,100	
(2) Buildings, including administration, service, maintenance, gate house, fire station, control buildings and laboratories	3,100	
(3) Special facilities including gasification, processing, storage and off gas treatment systems	73,800	
(4) Utilities, including water and electric power generation	3,000	
Subtotal		120,000
c. Contingency at 25% of above cost		30,000
Total Construction Project Cost		$ 150,000

11. Total Project Funding Requirements: a/	Prior to FY 1977	FY 1977	FY 1978	Future Years	Total
a. Direct Project Funding					
(1) Construction Project	$ 0	$ 7,300	$ 36,000	$ 106,700	$150,000
(2) CP&D	0	0	0	0	0
(3) R&D Prerequisite to Construction	0	10,800	35,200	3,100	49,100
(4) Expense Funded Equipment	0	0	0	0	0
(5) Other project related costs (start-up, training of personnel, operations)	0	0	0	6,200	6,200
Total Direct Project Funding	$ 0	$18,100	$ 71,200	$ 116,000	$205,300
b. Other Related Annual Funding Requirements				Annual Estimates	
(1) Facility Operating Costs				$ 3,400	
(2) R&D Operating Expenses directly related in the facility				0	
(3) Capital Equipment Not Related to Construction but related to R&D in the facility				0	
(4) GPP or other construction related to R&D in the facility				0	
(5) Other Costs				0	
Total Other Related Annual Funding Requirements				$ 3,400	

a/ Funds have not yet been fully appropriated for this program. Indicated amounts are estimated obligational authority required.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

76-1-c Low Btu fuel gas demonstration plant, site undetermined — Coal Program

12. Method of Performance

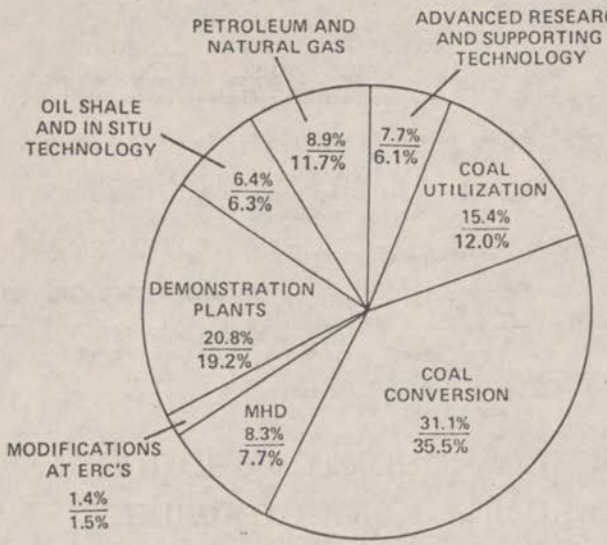
The project will be conducted in three Phases:

Phase I	Conceptual Design
Phase II	Plant Design and Construction
Phase III	Plant Operations

Phase I will be accomplished at Government expense. Phases II and III will be cost shared 50/50 with an industry partner.

To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bids.

FOSSIL ENERGY BUDGET ESTIMATES
DISTRIBUTION OF FUNDS



PERCENTAGE DISTRIBUTION OF FOSSIL ENERGY BUDGET ESTIMATES IN FY 1977 AND FY 1978 SHOWN AS FOLLOWS:

FY 1977%
FY 1978%

BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 77	FY 78	INCREASE DECREASE
COAL CONVERSION	$150.3	$233.3	$ +83.0
COAL UTILIZATION	74.4	79.1	+ 4.7
ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY	37.1	40.3	+3.2
DEMONSTRATION PLANTS	100.3	125.9	+ 25.6
MAGNETOHYDRODYNAMICS (MHD)	40.0	50.5	+10.5
PETROLEUM AND NATURAL GAS	43.2	76.7	+33.5
OIL SHALE AND IN SITU TECHNOLOGY	31.0	41.5	+10.5
MODIFICATIONS AT ERC'S	6.9	9.6	+2.7
TOTAL	$483.2	$656.9	$+173.7

FOSSIL ENERGY BUDGET ESTIMATES
BREAKDOWN OF FUNDS BY R&D AGENCY
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	(% OF TOTAL)	FY 1978	(% OF TOTAL)
ENERGY RESEARCH CENTERS	$ 47.0	(9.7)	$ 60.9	(9.3)
NATIONAL LABORATORIES	35.2	(7.3)	34.0	(5.2)
UNIVERSITIES	18.2	(3.8)	26.1	(4.0)
INDUSTRY	375.9	(77.8)	526.3	(80.1)
GENERAL PLANT AND EQUIPMENT, CONSTRUCTION, OSHA AND ENVIRONMENT AT ENERGY RESEARCH CENTERS	6.9	(1.4)	9.6	(1.4)
TOTAL	$483.2		$656.9	

COAL CONVERSION
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
LIQUEFACTION	$73.0	$107.4	+ 47.1
HIGH BTU GASIFICATION	$44.2	$ 51.5	+ 16.5
LOW BTU GASIFICATION	$33.1	$ 74.4	+124.8

1977 ACCOMPLISHMENTS

- H-COAL PILOT PLANT CONSTRUCTION UNDERWAY
- COMPLETE CONSTRUCTION 10 TON PER DAY SYNTHOIL PDU
- SUCCESSFULLY START UP BIGAS, SYNTHANE AND STEAM IRON PILOT PLANTS
- COMPLETE REFIT OF CRESAP TEST FACILITY FOR ADVANCED TECHNOLOGY TESTING

1978 CHANGES

- CONTINUOUS OPERATION OF PRESSURIZED FLUID-BED GASIFIER
- MAJOR CONSTRUCTION OF HYDROGEN FROM COAL FACILITY
- INITIATE DONOR SOLVENT PROCESS PILOT PLANT DESIGN AND LONG LEAD ITEM PROCUREMENT
- INITIATE PILOT PLANT PHASE OF CATALYZED GASIFICATION PROCESS
- MAJOR CONSTRUCTION OF LOW BTU GASIFICATION COMBINED CYCLE PILOT PLANT (POWERTON)

ISSUES/PROBLEMS

- CONTINUED UTILIZATION OF EXISTING PILOT PLANT FACILITIES
- EXTENT OF FUTURE DEVELOPMENT WORK IN HIGH BTU GASIFICATION

COAL UTILIZATION
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
ADVANCED POWER SYSTEMS	$22.5	$25.7	+14.2
DIRECT COMBUSTION	$51.9	$53.4	+ 2.9

1977 ACCOMPLISHMENTS

- COMPLETED 1000 HR COMBUSTION TEST OF COAL-OIL SLURRY IN A 100 HP BOILER
- MULTIPLE CONTRACTS AWARDED ON INDUSTRIAL AND INSTITUTIONAL APPLICATIONS OF AFB COMBUSTION
- OPEN CYCLE GAS TURBINE EFFORTS UNDERWAY ON VANE AND BLADE COOLING, CERAMIC COMPONENT AND MATERIAL TESTING
- BEGIN OPERATION OF 30 MWe FLUIDIZED-BED BOILER PROJECT IN RIVESVILLE, W. VA.
- MULTIPLE CONTRACTS AWARDED TO DEMONSTRATE COMBUSTION OF COAL-OIL MIXTURES IN EXISTING BOILERS

1978 CHANGES

- BEGIN CONSTRUCTION OF ATMOSPHERIC AND PRESSURIZED FLUIDIZED-BED COMBUSTION CTIU
- BEGIN CONSTRUCTION OF THE 13 MWe PRESSURIZED, FLUIDIZED-BED COMBINED CYCLE PILOT PLANT
- FABRICATION OF PROTOTYPE AFB COMBUSTION SYSTEMS FOR INDUSTRIAL APPLICATIONS
- LONG-LEAD PROCUREMENT FOR OPEN CYCLE GAS TURBINE TO PERMIT VERIFICATION TESTING

ISSUES/CHANGES

- FEASIBILITY OF COMBINED CYCLE
- FLUIDIZED BED COMBUSTION, STACK GAS SCRUBBING, COAL BENEFICATION TRADE-OFFS

ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY MATERIALS AND EXPLORATORY RESEARCH BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGES (%)
$29.3	$31.9	+8.9

1977 ACCOMPLISHMENTS

- DEVELOPED SIGNIFICANTLY LOWER COST, ENVIRONMENTALLY ACCEPTABLE PROCESS TO MAKE GASOLINE FROM COAL
- COMPLETED PROCESS RESEARCH ON NOVEL, SIGNIFICANTLY CHEAPER CATALYTIC COAL GASIFICATION PROCESS
- CORROSION STUDY ON CONSTRUCTION ALLOYS UNDER COAL GASIFICATION CONDITIONS
- MADE SIGNIFICANT PROGRESS IN DETERMINING RELIABLE MATERIALS AND VALVES FOR COAL CONVERSION PLANTS
- INITIATED STARTER GRANT PROGRAM TO STIMULATE FOSSIL ENERGY RESEARCH AT UNIVERSITIES

1978 CHANGES

- NEW EMPHASIS ON EXPLORATORY RESEARCH TO REDUCE COST OF PRODUCING SYNTHETIC FUELS FROM COAL
- COMPLETE LAB DEVELOPMENT OF PROMISING PROCESSES FOR SCALE UP OF FOSSIL TECHNOLOGIES

ISSUES/PROBLEMS

- RELIABLE MATERIALS AND COMPONENTS FOR COAL CONVERSION
- ACHIEVEMENT OF MAJOR PROCESS IMPROVEMENTS

DEMONSTRATION PLANTS
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
OPERATING EXPENSES	$53.0	$50.9	− 4.0
PLANT AND CAPITAL EQUIPMENT	47.3	75.0	+ 58.6
	$100.3	$125.9	+ 25.5

1977 ACCOMPLISHMENTS

- RE-EVALUATED CLEAN BOILER FUEL PROGRAM
- INITIATED CONCEPTUAL DESIGN OF HIGH-BTU SYNTHETIC PIPELINE GAS DEMONSTRATION PLANT
- INITIATED CONCEPTUAL DESIGN OF INDUSTRIAL LOW-BTU FUEL GAS DEMONSTRATION PLANT
- INITIATED CONCEPTUAL DESIGNS FOR SMALL INDUSTRIAL LOW-BTU FUEL GAS DEMONSTRATION PLANT

1978 CHANGES

- BEGIN CONSTRUCTION OF HIGH-BTU SYNTHETIC PIPELINE GAS DEMONSTRATION PLANT AND LOW-BTU FUEL GAS DEMONSTRATION PLANT
- START DESIGN FOR DIRECT COMBUSTION DEMONSTRATION PLANT
- START DESIGN FOR SOLVENT REFINED COAL DEMONSTRATION PLANT

ISSUES/PROBLEMS

- COST SHARING FOR MAXIMUM INDUSTRY PARTICIPATION
- OPTIMUM PROJECT MIX TO MAXIMIZE PROGRAM BENEFITS
- RELATIONSHIP TO ALTERNATIVE FUELS DEMONSTRATION PROGRAM

MAGNETOHYDRODYNAMICS (MHD)
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGES (%)
$40.0	$50.5	+26.2

1977 ACCOMPLISHMENTS

- INITIATED CONSTRUCTION OF CDIF TEST BUILDING
- INITIATED DEVELOPMENT OF FIRST CDIF GENERATOR CHANNEL
- DELIVERED BY-PASS SUPERCONDUCTING MAGNET FOR SOVIET U-25 FACILITY
- INITIATED MHD SUPERCONDUCTING MAGNET FOR CDIF
- INITIATED ETF SYSTEMS ENGINEERING AND CONCEPTUAL DESIGN

1978 CHANGES

- INITIATE DEVELOPMENT OF 2ND CDIF POWER TRAIN
- INITIATE HIGH PERFORMANCE GENERATOR CHANNEL TESTING AT AEDC
- INCREASE SYSTEMS AND DESIGN ANALYSIS TO SUPPORT AND GUIDE COMPONENTS DEVELOPMENT AND INTEGRATION
- DELIVER MHD GENERATOR FOR TESTING IN SOVIET U-25 FACILITY

ISSUES/PROBLEMS

- COMBUSTOR AND CHANNEL PERFORMANCE
- SEED/SLAG MANAGEMENT

PETROLEUM AND NATURAL GAS
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGE (%)
$43.2	$76.7	+77.5

1977 ACCOMPLISHMENTS

- INITIATED THREE COST-SHARED FIELD TESTS FOR ENHANCED OIL RECOVERY
- DETERMINED CHEMICAL SUPPLY AND DEMAND FOR MICELLAR-POLYMER AND CO_2 PROCESSES
- COMPLETED PROJECT PLAN FOR CHARACTERIZATION AND STIMULATION OF EASTERN GAS SHALE (DEVONIAN SHALE PROJECT)
- INITIATED TWO PROJECTS TO INCREASE DRILLING SPEED AND REDUCE DOWN TIME
- IMPLEMENTED IMPROVED MANAGEMENT PLAN FOR ENHANCED OIL RECOVERY
- COMPLETED PROJECT PLAN FOR CHARACTERIZATION AND STIMULATION OF WESTERN TIGHT GAS SANDS

1978 CHANGES

- PILOT TESTING TO DETERMINE ECONOMICS OF MICELLAR-POLYMER PROCESS
- EMPHASIZE STEAM FLOODING EXPERIMENTS AT VARIOUS LOCATIONS
- NEW START IN THERMAL RECOVERY OF OIL - TECHNOLOGY EMPHASIZED IN MANAGEMENT PLAN
- IMPLEMENT IMPROVED MANAGEMENT PLAN FOR ENHANCED GAS RECOVERY
- ACCELERATE EASTERN GAS (DEVONIAN) SHALE PROJECT

ISSUES/PROBLEMS

- KNOWLEDGE BASE VS IMPLEMENTATION FOR ENHANCED OIL RECOVERY
- DEVELOPING VIABLE TECHNOLOGY FOR ENHANCED GAS RECOVERY

OIL SHALE AND IN SITU TECHNOLOGY
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGES (%)
OIL SHALE	$22.8	$28.9	26.8
IN SITU COAL GASIFICATION	$ 8.2	$12.6	53.7

1977 ACCOMPLISHMENTS

- COMPLETED COST-SHARING CONTRACTS FOR SEVERAL IN SITU RETORTING EXPERIMENTS
- COMPLETED DIRECT-COMBUSTION SHALE-OIL PRODUCTION TEST AT ROCK SPRINGS, WYOMING
- INITIATED MICHIGAN ANTRIM SHALE GASIFICATION PROJECT
- COMPLETED LINKED VERTICAL-WELLS PROCESS (LVW) TEST
- INITIATED FIELD GASIFICATION TESTS ON PACKED-BED PROCESS
- STARTED FIELDING FIRST COMBUSTION TEST ON DIRECTIONAL WELLS
- DESIGNED STEEPLY-DIPPING-BED (SDB) PROJECT WITH INDUSTRY

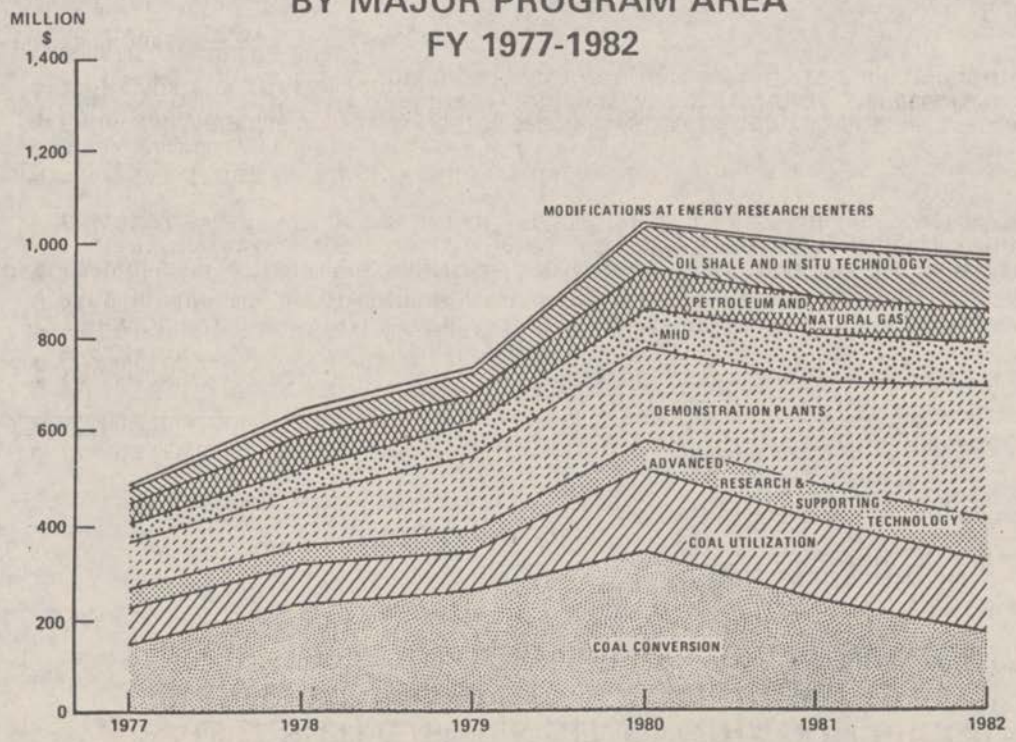
1978 CHANGES

- COMPLETE DESIGN OF A MULTI-TON OIL SHALE GASIFICATION FACILITY
- BEGIN HANNA IV LVW FIELD TEST
- CONDUCT THE FIRST STEAM/OXYGEN IN SITU GASIFICATION TEST AT HOE CREEK 2
- START SDB FIELD TEST PROGRAM

ISSUES/PROBLEMS

- ENVIRONMENTAL IMPACTS AND ACCEPTABILITY
- FUTURE OF IN SITU VS ABOVE GROUND SHALE OIL PRODUCTION
- DEVELOPING ACCEPTABLE ECONOMIC INCENTIVES FOR OIL SHALE
- MARKETS FOR IN SITU COAL GASIFICATION PRODUCTS

FOSSIL ENERGY OVERVIEW
BUDGET AUTHORITY DISTRIBUTION
BY MAJOR PROGRAM AREA
FY 1977-1982



ALTERNATIVE FUELS DEMONSTRATION PROGRAM
PROPOSED LEGISLATION
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978
ADMINISTRATION	$0	$ 3
DEMONSTRATION PROJECTS	0	297
	$0	$300

PROGRAM OBJECTIVES

- TO DEMONSTRATE AT COMMERCIAL SCALE, PROMISING, ENVIRONMENTALLY ACCEPTABLE COAL AND OIL SHALE PROCESSES
- TO ENCOURAGE INDUSTRIAL PARTICIPATION IN COMMERCIAL DEMONSTRATION PROJECTS BY PROVIDING PARTIAL FUNDING, OR OTHER FINANCIAL INCENTIVES, AS A MEANS OF SHARING RISK
- TO ACCELERATE THE DEVELOPMENT OF A SYNTHETIC FUELS INDUSTRY BY INVESTIGATING FINANCIAL, ENVIRONMENTAL, ECONOMIC, INSTITUTIONAL, AND OTHER POTENTIAL PROBLEMS PRIMARILY THROUGH FINANCIAL INCENTIVES IN SUPPORT OF "FIRST-OF-A-KIND" COMMERCIAL PLANT PROJECTS

PROGRAM STRATEGIES

- ERDA WILL PROPOSE TO THE CONGRESS SPECIFIC PROJECTS AND PROJECT RELATED AUTHORIZATIONS AND APPROPRIATIONS FOR VARIOUS TECHNOLOGY AREAS. CANDIDATE PROJECTS MAY INCLUDE PLANTS OF THE FOLLOWING TYPES: OIL SHALE, HIGH-BTU GAS, SUBSTITUTE FUEL (INDUSTRIAL FUEL GAS), AND SUBSTITUTE BOILER FUELS

ISSUES/PROBLEMS

- SOCIO-ECONOMIC IMPACTS AND COSTS
- INCENTIVE TYPE(S) TO BE EMPLOYED
- OPTIMUM PLANT SIZE AND MIX TO BE DEMONSTRATED

PREPARED STATEMENT

Mr. YATES. Were there other statements from any of the others?
Dr. MANNELLA. Yes.
Mr. YATES. That may go into the record at this point.
[The statement follows:]

STATEMENT OF DR. GENE G. MANNELLA, ACTING ASSISTANT ADMINISTRATOR FOR CONSERVATION, ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION—FISCAL YEAR 1978 APPROPRIATION HEARINGS

INTRODUCTION

Mr. Chairman and members of the committee: I am appearing before you today to provide an overview of the end-use conservation programs of the Energy Research and Development Administration. This includes programs in Industrial Energy Conservation, Buildings and Community Systems, Transportation Energy Conservation and Improved Conversion Efficiency.

For fiscal year 1978 we are requesting $234.9 million in budget authority for operating expenses and plant and capital equipment. This represents an increase of $134.0 million over fiscal year 1977. The revised fiscal year 1978 request includes $233.2 million in budget authority for operating expenses, and $1.7 million for supporting capital equipment. The $233.2 million request for operating expenses includes a $7.0 million amendment to provide increased emphasis on important energy initiatives in fuel cells, waste heat recovery and gas-fired heat pumps.

In fiscal year 1978 the conservation programs are broadened to emphasize near-term research and development. For example, the revised fiscal year 1978 request for transportation will support research and development for the Electric and Hybrid Vehicle Act (P.L. 94–413). Funds are also included for the continuation of the Energy Extension Service pilot program. The proposed fiscal year 1978 program will increase the effectiveness of our work to improve the efficiency of energy utilization in industrial processes, residential and commercial buildings, and transportation. The fiscal year 1978 request provides for a vigorous but balanced program in energy R.D. & D., building on a solid base of accomplishments over the past 2 years. We intend to continue to pursue a vigorous R. & D. program to provide the energy options that are so vital to our Nation's health and well being.

ORGANIZATION

The conservation program is organized into several broad areas with varied missions and methods for achieving goals and milestones. For example, in transportation the main thrust is to work with industry to commercialize fuel-efficient heat engines and electric vehicles in the shortest possible time. In the buildings area, our approach is to develop and demonstrate new energy saving technologies for incorporation in both new and existing structures. In the industrial and energy conversion areas, the approach is to complement industry's interest in improved efficiency by supporting high-risk, high-payoff process developments and improvements.

ACCOMPLISHMENTS

I believe the conservation programs have made considerable progress this past year. Among the accomplishments that I would cite as being particularly noteworthy are these:

We successfully completed a durability test on the baseline gas turbine engine. The engine accumulated the equivalent of over 150,000 miles under stringent test conditions.

We have completed the design on and have broken ground for a pilot scale plant to produce methane from urban wastes by anaerobic digestion.

We entered into a joint ERDA/Industry program to develop fuel cells. System design has been completed on a 4.8 MW fuel cell powerplant and construction design confirmation is proceeding. Long leadtime components have been ordered, permitting delivery of a 4.8 MW fuel cell in mid-1978 for test and evaluation on a utility system.

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These projects reflect the diversity of our development efforts. With the revised fiscal year 1978 request, a much more vigorous conservation program will be mounted in many areas, especially on near-term energy saving projects. Next, I will summarize the revised fiscal year 1978 request for each of the conservation programs.

SUMMARY OF FISCAL YEAR 1978 REQUEST BY PROGRAM

Industrial Energy Conservation.—The industrial energy conservation program is directed toward increased efficiency in energy utilization and increased use of nonpetroleum based fuels in the industrial/agricultural sector. Industry now consumes about 42 percent of the total U.S. energy and is extremely broad in scope. It is estimated that between 30 and 50 percent of this energy could be saved through the universal application of existing, emerging and advanced technologies.

The revised fiscal year 1978 budget is a 73 percent increase over fiscal year 1977 which will accelerate and expand some key projects previously started and bring many prior starts into the demonstration phase. A total of 80 percent of the fiscal year 1978 funding will be allocated to advancing projects previously started. Such projects include waste heat recuperators, heat pumps, Brayton bottoming cycles, energy-integrated industrial parks, continuous casting of steel, direct reduction of aluminum, coal as a feedstock for acetylene, aluminum smelter modifications and industrial waste recovery systems.

In addition, the increase will afford a number of key new project starts to capitalize on some of the important known but untapped opportunities for near and mid-term energy impacts. These include oxygen enriched combustion, conversion of waste polypropylene to fuel, dry coke quenching, plate food recovery for pet food, advanced irrigation systems, alternative food preservation and packaging systems, advanced paper processes, improved furnaces and computer controls in chemical plants.

The fiscal year 1978 Industrial Conservation program will be broadened and intensified to emphasize cost-shared partnerships with the private sector.

Buildings and community systems

The objective of the buildings and community systems program is to accelerate the introduction and use of new technologies and methods to lead to more efficient use of energy in new and existing buildings, community systems and consumer products. The program is organized into four major thrusts: 1. Building design and structure; 2. Community energy utilization, including urban waste; 3. Technology and consumer products and 4. Technology dissemination and transfer. All activities are directed at providing new technologies within a framework that is both economically and environmentally sound and which lessens the need for curtailment.

During the past year, some of the progress made in this program includes: 1. Construction and initial data collection on some experimental facilities: Annual cycle energy system (ACES); minimum energy dwelling (MED); and a fast-food restaurant. 2. Design and groundbreaking for a pilot scale plant to produce methane from urban waste by anaerobic digestion. 3. Development of a model energy code for new buildings agreed upon by the major code making organizations.

The fiscal year 1978 budget request allows for a balanced aprpoach between the thrusts applicable to the near-term (building design and structure, consumer products); and mid- to long-term (community systems, urban waste, new technologies). Examples of some of the efforts include:

Development of more efficient methods of utilizing energy in existing hospitals and schools particularly as related to ventilation equipment and heat recovery systems;

R. D. & D. efforts leading to the development of building standards which are to be issued by HUD by August 1979 in accordance with title III, Public Law 94-385, Energy Conservation and Production Act.

Demonstration of total energy system which will balance a community's energy needs and energy supply while conserving energy and imported fuels.

Projects which investigate the production of methane from solid waste such as the Anaerobic UpFlow (ANFLOW) digestor process.

Development and commercialization of more efficient systems and materials for buildings. Included in this is the demonstration of a high seasonal performance heat pump for the North-Central United States.

Development of methodology and studies of secondary impacts (employment, environment, materials) of use of more efficient technologies in the buildings sector.

Transportation energy conservation

The fiscal year 1978 transportation program includes increased efforts in three major categories of work, each focusing on reducing petroleum energy consumption in the Transportation Sector and eventually eliminating the current total dependence of the Sector on petroleum energy.

The first major area is development of new energy efficient automotive engines (the gas turbine and Stirling cycle systems), new vehicle subsystems (transmissions and regenerative braking), and resolving the practical problems associated with use of non-petroleum base fuels such as alcohols, fuels from coal and shale, in highway vehicles.

The second major area of work in the budget request is the implementation of the Electric and Hybrid Vehicle Act of 1976. The fiscal year 1978 request includes procurement of vehicles for demonstration required under the Act, provisions for loan guarantees, and additional funds to accelerate the pace of development of batteries and other key components of electric and hybrid vehicles.

The third major category of work focuses on several areas: Nonhighway energy consumption, specifically work on cooperative programs with other Government Agencies (FAA, UMTA, etc.); technology assessment activities in which we are determining the social, economic, and environmental consequences of implementing the new technologies under development, and finally, the transportation data analysis activity which serves as the energy data collection center for our total transportation activity.

We have accomplished much over the past year. A few of these accomplishments include:

Completed designs for advanced Stirling engine (80–100 hp).

Demonstrated a new transmission in an automobile with a 25 percent improvement in fuel economy.

Completed preliminary designs for three competing versions of electric vehicles.

Initiated testing and evaluations of state-of-the-art electric vehicles to determine baseline.

Completed publication and widespread dissemination of first edition of Transportation Energy Conservation Data Book.

Improved conversion efficiency

The improved conversion efficiency subprogram develops the technology base necessary to permit implementation of advanced conversion devices applicable to all fuel sources and to the end use sectors of buildings, community systems, industry, transportation, and electric utilities. To achieve this overall objective, generic supporting conversion technology will be developed; e.g., chemical to electrical, chemical to thermal, thermal to mechanical. The concept of a transition from oil and gas to alternate fuels in conversion devices is a major factor throughout the program.

Major R. & D. efforts include research and technology development in fuel cells, combustion and alternate fuels, waste heat utilization, dispersed power cogeneration, components and heat engines, recovery of methane from coalbeds and contaminated and shut-in natural gas wells, and supporting technology.

Major accomplishments through fiscal year 1977 include: Establishing a joint program between ERDA, the Electric Power Research Institute (EPRI), and United Technologies Corp. to develop and demonstrate a 4.8 MW fuel cell powerplant; identified fuel cells (40 KW) as the most promising prime mover for integrated energy systems; initiated development of more efficient gas turbines utilizing lower grade petroleum or alternate fuels; signed a cooperative agreement with industry to develop and demonstrate a 600 KW organic Rankine bottoming cycle for utility diesels; initiated studies for the recovery of methane from coalbeds.

The additional funding for fiscal year 1978 will result in the following increased efforts:

Demonstration of the 4.8 MW fuel cell on a utility grid; continue R. & D. of 40 kW system; fabricate and test a 120 kW fuel cell utilizing waste hydrogen; expand molten carbonate, second generation technology development.

Initiate efforts for introduction of 100 MW gas turbines utilizing heavy fuels by early 1980's.

Design, fabrication, and preparation for Lysholm helical expander hot tests in fiscal year 1979.

Initiate studies of technical options, driving forces, and retarding factors for cogeneration.

In cooperation with the Bureau of Mines to investigate the recovery of methane from coalbeds and shut-in gas wells.

Increase number of concepts for near term efficiency improvement for internal combustion engines.

ENERGY EXTENSION SERVICE

Funds were appropriated in 1977 to initiate the first year of a 2-year pilot Energy Extension Service program. An additional $8 million in budget authority is requested in 1978 to complete tests of various active outreach services, to evaluate the efficacy of such a program, and to determine what role such a service could have on a continuing basis within the framework of our developing energy policy and the proposed Department of Energy.

I have members of my staff available today to help respond to your questions. Thank you.

CONSERVATION RESEARCH AND DEVELOPMENT

[In millions of dollars]

	Fiscal year 1977 appropriation		Fiscal year 1978					
			Previous estimate to Congress		Amendment		Amended estimate to Congress	
	Budget authority	Budget outlay	Budget authority	Budget outlay	Budget authority	Budget outlay	Budget authority	Budget outlay
Operating:								
Industrial energy conservation	14.4	12.0	25.0	18.1	0	0	25.0	18.1
Buildings and community systems	26.6	22.6	52.0	42.8	2	1.0	54.0	43.8
Transportation energy conservation	27.2	23.8	86.0	56.0	0	0	86.0	56.0
Improved conservation efficiency	23.2	12.4	55.2	45.2	5	3.5	60.2	48.7
Subtotal end-use conservation	91.4	70.8	218.2	162.1	7	4.5	225.2	166.6
Energy extension service	7.5	5.0	8.0	6.0	0	0	8.0	6.0
Total operating	98.9	75.8	226.2	168.1	7	4.5	233.2	172.6
Capital equipment	2.0	.9	1.7	1.2	0	0	1.7	1.2
Grand total	100.9	76.7	227.9	169.3	7	4.5	234.9	173.

BIOGRAPHIES OF KEY FOSSIL ENERGY DIVISION PERSONNEL

Mr. YATES. As I read Dr. White's statement, he pointed out the breakdown of the new setup of ERDA's fossil energy organization and with respect to the heads of each of the divisions that make up this setup, would you be kind enough to submit for the record a biography for each of those people.

[The information follows:]

Dr. Philip C. White, Assistant Administrator for Fossil Energy, Energy Research and Development Administration, directs the Federal Government's research and development efforts toward developing techniques to enhance the recovery of oil and gas, to develop means of converting shale to synthetic oil and to better utilize our coal reserves by converting them to synthetic liquid and gaseous fuels. Prior to his appointment by President Ford, Dr. White was general manager of research for the Standard Oil Co. of Indiana. He joined the Standard Oil Co. in 1938 after receiving a Ph. D. degree in organic chemistry from the University of Chicago. He has served terms as president of the Industrial Research Institute, the Coordinating Research Council, and as the U.S. representative to the World Petroleum Congress.

Dr. S. William Gouse, Jr., was appointed Deputy Assistant Administrator for Fossil Energy, effective January 19, 1975.

Dr. Gouse was Acting Director of the Department of Interior's Office of Coal Research which was transferred into the new energy agency on January 19, 1975. He had been Director of the Office of Research and Development, and Science Advisor to the Secretary of the Interior from October 1973 to January 1974.

Dr. Gouse received his Bachelor of Science and Master of Science (Mechanical Engineering) degrees in 1954 from the Massachusetts Institute of Technology. He was awarded a Doctor of Science degree in 1958, also from MIT. Dr. Gouse is a registered professional engineer in the State of Massachusetts.

Included among Dr. Gouse's many professional activities is 13 years of research and teaching at MIT, where he was an assistant professor (1958–65) and an associate professor (1965–67). From 1961 to 1962, Dr. Gouse was with the Ballistic Research Laboratory, U.S. Army Ordnance Corps. He was a professor of mechanical engineering at the Carnegie Mellon University from 1967 to 1969. Dr. Gouse was technical assistant, Office of Science and Technology, Executive Office of the President from 1969 to 1970. He was an associate dean of the Carnegie Institute of Technology and the School of Urban and Public Affairs from 1971 to 1973, and during the same period, Dr. Gouse was director, Environmental Studies Institute at Carnegie Mellon University.

Besides numerous consulting assignments, Dr. Gouse has been a member of such professional societies as the American Institute of Aeronautics and Astronautics, the Steam Automobile Club of America, the American Association of the Advancement of Science, the Society of Automotive Engineers, Pi Tau Sigma, Sigma Xi, Tau Beta Pi, and the Solar Energy Society. He has received fellowships and awards, among them the General Electric Corp. Edwin W. Rice, Jr., Fellowship (1955–56), and the North Area Environmental Council (Allegheny County, Pa.) Award for Outstanding Service in 1973.

Among many public service activities, he has been Executive Secretary, Office of Science and Technology, Executive Office of the President Ad Hoc Panel on Unconventional Vehicle Propulsion (1969–70). He was a member of the National Science Foundation's Advisory Committee on Solar Energy in 1972.

Harry R. Johnson has been appointed Director, Office of Program Planning and Analysis, effective September 14, 1975.

Mr. Johnson was Assistant Director for Exploration and Extraction, Office of Research and Development, Department of the Interior, from May 1974 to January 1975 and Acting Director of that office until he joined ERDA in June 1975 as technical advisor in the fossil energy program. Previously, he was Assistant to the Assistant Director of Energy, Bureau of Mines.

Mr. Johnson was born April 17, 1938, in Pittsburgh, Pa. A 1960 graduate of the University of Pittsburgh in petroleum engineering and geology, he studied research management at American University and public administration and economics at the University of Washington in Seattle. He joined the Interior Department in 1960 to work on petroleum recovery research at the Bureau of Mines facility in Morgantown, W. Va. Mr. Johnson helped guide the Government in-house research program directed toward more efficient production and use of the Nation's fossil fuel resources. That program, conducted at the Bureau of Mines' (now ERDA's) Energy Research Centers, included the conversion of coal to clean gaseous and liquid products, and methods of stimulating natural gas and oil production and technology that will enable oil shale to be developed in harmony with its environment.

As Deputy Oil Shale Coordinator for the Interior Department, Mr. Johnson helped develop the prototype oil shale leasing program on public lands and was responsible for preparing a 3,200 page environmental statement on the program. He also was responsible for directing the oil shale task force for the project independence blueprint. Most recently, he has been on long-term assignment to the Office of Management and Budget as chairman of the technology and incentives working group for the President's synthetic fuels commercialization program.

Mr. Johnson and his wife, Louise, have a son, Raymond, and a daughter, Leslie. They live in Rockville, Md.

Mr. Johnson is located on the fourth floor of ERDA headquarters, 20 Massachusetts Avenue, NW.

James E. Langford has been appointed Director, Administrative Office, Fossil Energy. Mr. Langford had been serving as Acting Director since January, 1977.

Mr. Langford received his B.S. degree from Massachusetts State College in 1956, and a M.S. degree in public administration from George Washington University and a M.S. degree in management from Central Michigan University the following year. He also attended the Industrial College of the Armed Forces during the 1974 academic year.

Mr. Langford was with the National Aeronautics and Space Administration (NASA) prior to joining ERDA in 1976 as senior management/planning analyst, office of commercialization. From 1960 to 1969, he was industrial security manager with responsibility for developing NASA-wide standards, procedures and regulations governing the administration of the NASA industrial security program. He served as administrative officer, office of manned space flight from 1969 to 1973, and Senior management analyst, NASA office of institutional management from 1974 to 1975.

While at NASA Mr. Langford received numerous awards for his performance including the NASA superior achievement awards and sustained superior performance award. He has also received ERDA's certificate of appreciation.

Mr. Langford is located in room 4134 on the fourth floor of ERDA headquarters, 20 Massachusetts Avenue NW., and may be reached on extension 64640.

Dr. Martin Neuworth has been appointed Acting Director, Division of Coal Conversion and Utilization. Mr. Roland Beck will continue to serve as Deputy Director of the Division.

Dr. Neuworth was transferred into ERDA with the Office of Coal Research, where he served as Assistant Director for Liquefaction. He came to the Government in 1974 from private industry, where he was responsible for the development of chemical products. Dr. Neuworth worked for the Consolidation Coal Co., Library, Pa., for 22 years where his duties included supervising bench scale and pilot plant studies on coal and liquid products derived from coal processing. In 1969, he was named manager of research for Conoco Chemicals, Continental Oil Co., Wilton Conn., and later was promoted to director for product development for Conoco Chemicals.

Dr. Neuworth received his B.S. degree from City College of New York and his master and doctorate of science degrees from Carnegie Mellon University. Dr. Neuworth holds 55 U.S. patents related to coal and chemical processing and products.

Dr. Neuworth is located in room 403 at 400 First Street NW. and can be reached on 376-9307.

Dr. G. Alex Mills has been apponted Director, Division of Materials and Exploratory Research, Fossil Energy, effective September 14, 1975.

Dr. Mills had been Acting Director of the Division of Advanced Research and Supporting Technology since April 1975. Prior to his transfer to ERDA in January 1975, he was Assistant Director for Supporting Science and Technology, Office of Coal Research, U.S. Department of the Interior.

Born in Canada and now a U.S. citizen, Dr. Mills' career spans academic, industrial, and governmental research. He received his bachelor and masters degrees from the University of Saskatchewan and his Ph. D. degree in physical chemistry from Columbia University, before becoming an instructor in chemistry at Dartmouth College. While at Columbia, he assisted Professor Urey in early work on separation of isotopes by chemical means.

Dr. Mills' special technical field is catalysis, particularly as applied to hydrocarbon conversions. He joined Houdry Laboratories, Air Products and Chemicals Corp., in 1940, serving as director of research from 1952 to 1968. While there, he and his colleagues established the novel dynamic nature of catalyst surfaces and the existence of high energy strain sites. He directed work which led to DABCO, a molecule used internationally in plastics manufacture.

He then joined the Bureau of Mines in August 1968 as Chief, Division of Coal. In the Bureau of Mines, Dr. Mills supervised the Synthane coal gasification pilot plant and directed work on various other coal gasification and liquefaction processes. He holds 60 U.S. patents and is the auther of over 60 articles.

Dr. Mills and his wife, Roberta, have four children and reside in Bethesda, Md.

Dr. Mills will be located in room 4103 of ERDA headquarters, and may be reached on 376-4624.

Mr. George A. Rial has been appointed Director, Division of Major Facility Project Management, effective September 8, 1975.

Mr. Rial received his B.S. degree in chemical engineering from Carnegie Mellon University, Pittsburgh, Pa., in 1936. He was awarded an M.S. degree in chemical engineering from Columbia University, New York City, in 1941.

Prior to his appointment, Mr. Rial was vice president—Technology for the Interpace Corp., Parsippany, N.J. In this capacity, he had functional responsibility for the corporation's total technical program. From 1936 to 1956, he performed various supervisory and working assignments for the Exxon Research and Engineering Co.; including plant design, start-up, and trouble shooting. In 1956, he was appointed assistant director, products research division, where he was responsible for Exxon's research on motor fuels. From 1958 to 1967, he worked in the Esso Standard Eastern headquarters followed by an assignment in Australia, where he was manufacturing director with responsibility for petroleum refining, chemical manufacturing, petroleum supply and transportation, engineering and economic studies, and process planning. From 1967 to 1972, he served as project manager on several of Exxon's petroleum refining projects.

Mr. Rial is located on the fifth floor of ERDA's 400 First Street office and may be reached on 376–9384.

Dr. William D. Jackson has been named Director of ERDA's program to develop the coal-to-electricity system known as Magnetohydrodynamics (MHD). Dr. Jackson came to ERDA with the transfer of the former Office of Coal Research from the Department of Interior and was named Acting Director of the Division of MHD when it was established in August 1975.

Dr. Jackson is a native of Edinburgh, Scotland, and first came to the United States as a Fulbright scholar in 1955. He obtained B.S. and Ph. D. degrees from the University of Glasgow, Scotland, where his doctoral dissertation was in the field of Magnetohydrodynamics. He attended the Massachusetts Institute of Technology (MIT), Cambridge, Mass., where he became established in MHD power generation technology, and since then has been continuously involved in MHD and other energy research and development activities and in project management with several industrial, academic and Government organizations. As Director of the MHD Division, he has extensively participated in international activities, including membership of the IAEA/UNESCO Jont Liaison Group on MHD Electrical Power Generation. He is the U.S. Cochairman of the Steering Committee for the Cooperative Program in MHD Power Generation being conducted jointly with the Soviet Union under the U.S.–U.S.S.R. energy agreement.

Dr. Jackson is a fellow of the United Kingdom Institution of Electrical Engineers and was awarded the ERDA special achievement award in 1976.

Dr. Jackson is located in room 6123 and can be reached on 376–4630.

Hugh D. Guthrie has been appointed Director of the Division of Oil, Gas, and Shale Technology, Fossil Energy, the Energy Research and Development Administration announced today. Guthrie, currently an engineer with the Shell Oil Co., will assume the position on June 7.

Since November 1975, the 57-year-old native of Murdo, S. Dak., had been part of a special team to assess planning and management practices at Shell's headquarters in Houston, Tex.

Guthrie started his career in 1943 as an engineer with the Shell Development Co.'s research center at Emeryville, Calif., later moving to its offices in San Francisco and Wilmington. He moved to Shell Oil in 1952 as a technologist for process engineering work at the firm's Wood River, Ill., refinery. He subsequently held management positions at Shell offices in Wood River and New York City prior to transfer to the Houston headquarters in 1967.

The new Director served a term as president of the American Institute of Chemical Engineering, which brought him in contact with local sections, student chapters and national meetings. His experience includes teaching mathematics and English to inmates of San Quentin prison in California and lectures in chemical engineering at the University of California-Berkeley and Washington University, St. Louis, Mo.

Guthrie received his bachelor of science degree in chemical engineering at the State University of Iowa, Iowa City.

Mr. Edward J. Myerson has been appointed as Director of the Division of Commercial Applications in Fossil Energy. Mr. Myerson has been serving in this position in an acting capacity since November 21, 1976.

Mr. Myerson was previously Assistant Director for Finance and Incentives in the former Office of Commercialization. Mr. Myerson was Acting Director of the Office of Economic Regulation at the Federal Energy Administration (FEA) prior to joining ERDA. He originally served as a consultant to FEA and was

subsequently appointed Deputy Director of the Office of Energy Finance. Before his Government service, Mr. Myerson gained industrial engineering experience with Sperry Rand and Todd Shipyards and performed marketing assignments with Maxson Electronics and with Servonics, Inc., where he was vice president for marketing. Mr. Myerson was also associated with engineering for industry and served as president of both Teletray Electronic Systems, Inc., and Electronic Equipment Corp. In the financial world, he specialized in tax-oriented investments with Reynolds Securities, Inc., and Loeb, Rhoades & Co. Mr. Myerson received his B.S. degree in electrical engineering from the U.S. Naval Academy in 1946. He has done graduate study in finance and accounting at the New York Institute of Finance, George Washington University, and the Wharton School of Finance.

Mr. Myerson is located at ERDA Headquarters, 20 Massachusetts Avenue NW., in room 4113, and can be reached by telephone on 376–4406.

Mr. Marvin Singer has been appointed Director for the Division of Environmental and Socioeconomic Programs. In this position, he is responsible for maintaining expertise and a knowledge base to minimize environmental and socioeconomic impacts of fossil energy actions. He is responsible for the preparation of environmental impact statements of major fossil energy programs and projects and assists the other divisions in the preparation of environmental assessments.

Mr. Singer served previously as Assistant Director for Environmental and Socioeconomic Impact in the former Office of Commercialization. He served as a staff member of the President's Council on Environmental Quality (CEQ) from 1972 until he joined ERDA. While at CEQ, he specialized in the development of analytical approaches for energy and environmental policy analysis. Prior to his Government service, Mr. Singer was on the corporate planning staff of the Gulf Oil Corp. and analyzed mergers, acquisitions, and dispositions as well as national and international corporate planning programs. From 1964 to 1969, he was associated with the Gulf Research and Development Co. and performed preliminary design engineering and economic evaluations of refinery and petrochemical processes.

Mr. Singer received his B.S. degree in chemical engineering in 1963 from the Massachusetts Institute of Technology and an M.S. degree in chemical engineering from the Columbia University in 1964. He received an M.S. degree in industrial engineering and operations research from the University of Pittsburgh in 1970.

Mr. Singer is located in room 4117, 20 Massachusetts Avenue NW., Washington, D.C., and can be reached on 376–9086.

Mr. G. H. Gronhovd is the Director of Grand Forks Energy Research Center. Mr. Gronhovd received his B.S. degree in mechanical engineering from the University of North Dakota in 1950. He spent several years with the engineering test department of the J. I. Case Co., Racine, Wis., and 1 year with General Motors Corp., Milwaukee, Wis., before joining the U.S. Bureau of Mines Lignite Research Laboratory, Grand Forks, N. Dak., in 1953.

For the past 24 years Mr. Gronhovd has been involved in lignite research and development in the areas of storage, drying, combustion, gasification, carbonization and liquefaction. Since 1973 he has been Director of the Grand Forks Energy Research Center which in 1975 was transferred from the Department of the Interior Bureau of Mines to the Energy Research and Development Administration.

Mr. Gronhovd is a member of the American Society of Mechanical Engineers' National Research Committee on Corrosion and Deposition from Combustion Gases. He served for 3 years as a member of the Electric Power Research institute's task force on fossil fuels and is a member of the Society of Sigma Xi.

In 1976 Mr. Gronhovd represented the United States at an international conference on the utilization of low-calorie fuels, held in Varna, Bulgaria under the sponsorship of the United Nations. He is continuing cochairman, representing ERDA, in the widely recognized Lignite Symposia, a biennial series of conferences that concentrate on utilization of the low-rank coals.

Mr. Gronhovd is the author or coauthor of about 25 publications relating to the technology and use of lignite and other western coals.

John S. Ball, Director for the Bartlesville Energy Research Center of the Energy Research and Development Administration (ERDA), started with the Bureau of Mines in 1938 in Laramie, Wyo. For 25 years he was engaged in research on petroleum and shale oil at the Laramie Petroleum Research Center.

His research work involved the composition of petroleum and shale oil, with special reference to sulfur and nitrogen compounds, and resulted in a large number of scientific papers. He served as director of American Petroleum Institute Research projects 48 on sulfur compounds of petroleum and 52 on nitrogen compounds of petroleum.

In June 1953, he assumed duties as Research Director of the Bartlesville Petroleum Research Center—now known as the Bartlesville Energy Research Center. He was councillor for the northeast Oklahoma section of the American Chemical Society 1963–1971 and was chairman of the Division of Petroleum Chemistry of the American Chemical Society for 1965. He was managing editor of the division's preprints from 1969 to 1976. He is past president of the Oklahoma Institute of Chemists.

Ball received the B.S. in Ch.E. and M.S. degrees from Texas Technological College and attended the University of Colorado. He received the Jaycee's award as one of the outstanding young men in Federal service in 1953 and the Department of the Interior distinguished Award in 1954. He received the "distinguished engineer" designation from Texas Tech in 1977.

He is a fellow of the American Institute of Chemists and a member of the American Chemical Society, American Petroleum Institute, Society of Petroleum Engineers, The Geochemical Society, Sigma Xi, the Bartlesville Chamber of Commerce, and the Bartlesville Kiwanis Club. He is president of the Cherokee Area Council of the Boy Scouts of America.

Dr. Andrew W. Decora is Director of the Laramie Energy Research Center, a position he has held since December 1974. In this position he has responsibility for managing an energy research budget in fields of in situ recovery research of oil shale, tar sands, coal gasification, and petroleum and asphalt chemistry.

Prior to assuming his present position, Dr. Decora served as assistant to the assistant director for exploration and extraction of the Interior Department's Office of Research and Development. His recent major contributions have been through participation in the preparation of the environmental statement for the Department's prototype oil shale leasing program for which he received a commendation from Interior's Secretary, and through participation in the Federal Energy Administration's Project Independence study on oil shale. In 1976, he received ERDA's Distinguished Service Award for outstanding contributions in development of new organizational and management concepts to support the establishment of a viable and coordinated field organization and laboratory system.

Decora joined the U.S. Bureau of Mines in 1948 as a part time physical science aid. He remained with LERC after receiving his B.S. in chemistry at the University of Wyoming in 1950. While working at Laramie, Decora enrolled in graduate work at Wyoming University under a cooperative agreement between the Bureau of Mines and the University. He received his M.S. degree in 1957 and his Ph.D. in 1962 as a result of this work. Both his graduate degrees are in physical-organic chemistry.

Dr. Decora's previous work at the Laramie Center was in basic research related to the spectroscopy and the kinetics and mechanisms of shale oil components. He has performed research work in thermal, photo-chemical-, and oxidation-reactions of shale oil compounds and also performed research in infrared, ultraviolet, nuclear magnetic resonance, and mass spectroscopy. He is the author or coauthor of 20 publications in the above research areas. He has presented results of his research before local and national scientific societies.

Dr. Decora is a member of the American Chemical Society (ACS), Petroleum Division ACS, Fuel Division ACS, American Association for the Advancement of Science, American Society for Testing and Materials, Colorado-Wyoming Academy of Science, Sigma XI, and Toastmasters International. Dr. Decora is listed in seven biographical works, including American Men of Science and Who's Who in the West.

Augustine A. Pitrolo, Director, Morgantown Energy Research Center, Energy Research and Development Administration, Morgantown, W. Va., graduated from West Virginia University in 1952 with a B.S. degree in mechanical engineering. Subsequent education included graduate work at the University of Pittsburgh, University of Cincinnati, Xavier, and Pennsylvania State University.

He began his professional career with the Joy Manufacturing Co. in design and development of underground mining equipment. He then joined General Electric as a powerplant engineer involved in the design and development of aircraft gas turbines. Subsequently he served as systems manager in various

advanced space programs, followed by manager of G.E.'s space nuclear radioisotopic thermoelectric generator (RTG) programs. He managed the research technology, development, and production of SNAP-27 RTG's flown and deployed on each Apollo flight. He later became involved in the design and development of commercial gas turbines.

He joined the Energy Research and Development Administration as Director of the Morgantown Energy Research Center in 1975, where he is engaged in research and technology development of coal conversion into synthetic gas and oil, direct coal combustion, and extraction of oil and gas. Mr. Pitrolo is author of a number of papers, their subjects ranging from systems for auxiliary devices to heavy duty gas turbines. He was awarded the NASA public service Award in 1972.

Dr. Irving Wender, born in New York City in 1915, obtained his B.S. degree from City College of New York, his M.S. from Columbia University, and his Ph.D. from the University of Pittsburgh. He worked on the Manhattan project at the University of Chicago from 1943 until 1946 and joined the Bureau of Mines later that year. He became project coordinator, chemistry, in 1963, and was appointed research director of the Pittsburgh Energy Research Center in 1971. The Center, transferred in 1975 to U.S. Energy Research and Development Administration (EROA), is at the forefront in developing and piloting coal conversion processes.

Dr. Wender's researches have been in a variety of subjects, often interdisciplinary. He is well-known for his pioneering work on homogeneous catalysis by transition metal complexes, and for his many researches on coal chemistry and the conversion of coal to synthetic fuels. He has been involved in pioneering studies in the conversion of organic wastes to synthetic fuels.

Dr. Wender won the Storch Award in 1964; the Distinguished Service Award of the Department of the Interior in 1966; the Pittsburgh Award of the American Chemical Society, Pittsburgh section, in 1968; the K. K. Kelley Award of the Department of the Interior for his contributions to coal chemistry and to catalysis in 1969; and on November 16, 1976, was presented the National Civil Service League Award, symbolic of his contributions to public service and the welfare of our Nation. Only 10 of these awards are given annually by the League, a nonprofit citizens' organization established in 1883.

Dr. Wender has authored over 150 papers. He is a section editor of Chemical Abstracts for coal chemistry and has served as chairman of the National Fuel Chemistry Division of the American Chemical Society.

PRESIDENT CARTER'S ENERGY MESSAGE

Mr. YATES. Go ahead, Mr. Fri.

Mr. Fri.

Mr. Chairman and members of the committee, I appreciate the opportunity to appear before you today to discuss the Energy Research and Development Administration's request for appropriations for fiscal year 1978.

Last Wednesday President Carter outlined a national energy plan creating the framework for solving our national energy problems. The President's plan has fully integrated R.D. & D. activities into an overall approach which employs the full set of tools—regulatory, economic, and technological—necessary to deal with this country's most serious current problem.

Mr. WHITTEN. I didn't quite understand that message. Are you going to explain it?

Mr. FRI. I would be glad to do the best I can.

The President discussed three major strategies for achieving the objectives of the plan: Implementation of an effective conservation program for all sectors of energy use so as to reduce the rate of demand growth to less than 2 percent; the conversion by industry and utilities using oil and natural gas to coal and other more abundant fuels to reduce imports and make natural gas more widely available

for household use; and a vigorous research and development program to provide renewable and essentially inexhaustible resources to meet U.S. energy needs in the next century.

Because the plan heavily emphasizes conservation and coal and exotic sources of oil and gas, it has particular bearing on the programs that we are testifying on today, Mr. Chairman.

It will have a small budgetary impact which I will mention, although the necessary justification material will not be submitted until next week.

This revision emphasizes small-scale energy systems for solar and geothermal activities which will increase that budget by $28 million, further increase the fossil program by $17 million, and a $7 million increase in the conservation program which we can discuss in detail later.

FISCAL YEAR 1978 ERDA BUDGET REQUEST

For ERDA in total, we are now requesting appropriations totaling $7,305 million, of which $5,420 million is for operating expenses, and $1,714 million is for plant and capital equipment. Revenues, primarily from uranium enrichment activities, are estimated at $1,067 million assuming passage of necessary legislation to revise our charges for enriching services. Accordingly, total resources of $8,372 million will be available to ERDA in 1978. An analysis of our total budget by major functional areas is shown in charts II and III. Of particular interest is our energy R.D. & D. budget, a breakdown of which is shown in charts IV and V. Programs under the jurisdiction of this committee are shown in charts VI and VII.

As to the fiscal year 1978 programs under the jurisdiction of this committee, our request is for a total of $1,192 million, which is an increase of $608 million over the 1977 level. Conservation research and development increases in our proposed budget from $161 million to $325 million in budget authority or essentially a doubling of that program. The great bulk of that increase is in the end-use sector under the jurisdiction of this committee.

The fiscal year 1978 request in the end-use sector is $235 million, which is $134 million above the 1977 level.

Importantly, the transportation area includes $40 million to support the Electric and Hybrid Vehicle Act of 1976.

In the fossil area our request is up 36 percent from $483 million to $657 million.

We would be delighted to proceed with questions or to summarize the other statements, whichever you would prefer.

ENERGY RESEARCH AND DEVELOPMENT CONCENTRATION

Mr. YATES. Thank you for your statement.

Since its inception, ERDA has moved to pursue every possible technology and within each technology to follow multiple processes through pilot plant size stages. Is this being refined at all? I know as I read Dr. White's statement what you were going to do seemed so enormously comprehensive.

Are you going to concentrate on any particular field?

Mr. FRI. Let me try to answer that question in two ways. First of all, the thrust of the President's energy plan, which was first reflected in the February revision to our budget and again in the April revision which we will be submitting, tends to focus concentration on the fossil program, the conservation program and nearer-term applications of so-called renewable resources such as solar and geothermal. I think there is a new focus emerging in the near term, which fo us is 10 to 15 years, on the kind of applications which need to be pursued if we are to see a significant impact as a result of R. & D.

Internally we are about halfway through major planning exercises in which we have attempted to look at all of our technology in some detail from the standpoint of the market, and ask which technologies are really likely to penetrate given the prices we see for conventional and advanced technology fuels in the future. That study which is under Dr. White's leadership will give us a much better perspective on the right kinds of development strategies for each of our technologies.

For example, some technologies which have relatively short-term application will clearly come into the market with competitive prices given a successful R. & D. program. Those tend to be rather priority items for ERDA.

At the other extreme, there are those technologies which we determine would not enter the market, perhaps because of too high a price without something really remarkable happening in the outside world, like environmental restrictions being lifted or the Arabs running the price of oil up to $40 a barrel.

While we don't necessarily want to abandon those technologies, we might treat them more as hedges, as back-burner types of projects in case something really unpleasant happens. So we are in the process of trying to structure the program and give a better sense of relative priority to its various elements.

OPTIMISM IN OIL SHALE

Mr. YATES. Members of the committee from Western States are particularly concerned about coal and about oil shale. We have had some interesting testimony from time to time on oil shale. Witnesses from Occidental Petroleum appeared and indicated that its method of in-situ development could be competitive, could produce oil in competition with oil being sold at world prices. We had witnesses last week from the Institute of Gas Technology which indicated that they believed they had a method which would permit oil and gas from Devonian shale to be produced at $15 to $20 a barrel. Others have indicated that they are on the verge of moving into this field.

Is this as encouraging as these witnesses would indicate? In addition to that, we have members of the committee who have gone to the Paraho operation in Colorado and came away impressed with it.

Mr. FRI. I am more encouraged today than I have been. Obviously the technologies haven't changed; however, prices at least as indicated by the President, would increase and enhance the commercial liability of this technology. Technologically, the in-situ process and the surface retorting process seem to be going along well. Dr. White will comment on that in more detail.

DEVONIAN SHALE DEVELOPMENT

The Devonian shale project we started last year is moving along at an accelerated pace. I am optimistic about that.

What has happened is that the President has proposed a system of price increases and wellhead taxes that make industry, for example, look at the price of a barrel of distillate oil in the neighborhood of $21 a barrel by 1985, and would make industry look at a price of gas by 1985 that is about $3.25 per million Btu, which is substantially greater than today. The tax system would create a price that looks like that.

At those prices the cost of shale oil could be competitive.

Mr. YATES. At $21?

Mr. FRI. $21 per barrel of distillate shale oil would be competitive. It could be significantly lower than that if the R. & D. technology is successful. The point is, it is well within the possible cost of shale.

If Devonian shale technology is successful, it could come in at $2.50 to $3 per million Btu. Industry is going to be looking at a price of $3.25 if the proposed tax system goes into effect. Furthermore, Devonian shales gas could be exempted from the price ceiling imposed on regular natural gas so that the producer can recover his full cost.

Mr. DUNCAN. I have a question.

Mr. YATES. You caught him in midsentence.

Mr. DUNCAN. When you have completed.

Mr. FRI. Therefore, the producer can charge a price that will make a profit and still be perhaps equal to or less than the cost of natural gas and petroleum that industry and utilities would be seeing.

If that happens, these technologies will be much more attractive.

Mr. DUNCAN. This is what Mr. Whitten was probably talking about as far as his confusion, because you also have to exempt that production from this tax that artificially raises the price. You are not raising the wellhead price; you are raising the taxes that make it look like you are raising the price.

Mr. FRI. The gas from Devonian shale, as I understand it, would be exempted from the tax scheme and from the price ceiling so the producer of those shales could charge cost plus a reasonable profit. The full price of the gas would go to the producer in order to allow a return on the investment necessary to develop the shale. The exotic sources don't fit under the price-tax proposals for natural gas and normal petroleum.

Mr. DUNCAN. So you have two exemptions from the tax and an exception from the price limitation?

Mr. FRI. That is my understanding.

Mr. DUNCAN. Is all this being spelled out when it is coming up to the Congress?

Mr. FRI. I believe they will be. There is a 100-page document which will explain these proposals in detail which is to be available soon. There are also a few lines in the factsheet.

LEASING OF FEDERAL LAND FOR SECURING OIL SHALE

Mr. EVANS. I have a question. What role do you play, if any, in giving the go-ahead signal to some new exotic fuel? For example, if

Occidental were to think it was in a position to go ahead right now without government loans or guarantees or subsidies, and a decision had to be made as to whether or not they should be allowed to bid on some Federal lands to lease for the purpose of securing oil shale, would you get back into this procedure at all?

Mr. FRI. In the case where there is no Federal Government activity except in leasing, Federal action would entail an environmental impact statement. In the normal course of events, ERDA would probably be contacted to help evaluate the environmental effects of the proposed activity. But that would be the extent of our involvement.

Mr. EVANS. You would not be called in for a judgment as to whether or not they were able to produce under those circumstances?

Mr. FRI. If Occidental, for example, is the successful bidder on a Federal lease, it is largely their problem as to whether they get their money out of it or not. We might be asked but there is no big judgment of it.

HOUSE APPROPRIATION COMMITTEE STAFF ENERGY SURVEY

Mr. WHITTEN. I have another committee before long, and if you would excuse me I would like to ask two or three things.

Mr. YATES. We would be pleased if you would, Mr. Whitten.

Mr. WHITTEN. We asked in 1974—may I say at my insistence but joined in by all the subcommittee chairmen who have jurisdiction of any part of this—to make an investigation by the staff of the Appropriations Committee. That report was filed in 1975. Recently we asked that it be brought up to date. I don't have a copy at the moment but I would like it to be inserted in the record.

[The information follows:]

NOT FOR RELEASE UNTIL AUTHORIZED BY THE COMMITTEE

A REPORT TO

THE COMMITTEE ON APPROPRIATIONS

U.S. HOUSE OF REPRESENTATIVES

on the

ENERGY SURVEY

Surveys and Investigations Staff

March 1975

NOT FOR RELEASE UNTIL AUTHORIZED BY THE COMMITTEE

March 13, 1975

MEMORANDUM FOR THE CHAIRMAN

Re: Energy Survey

By directive dated August 20, 1974, the Committee requested that a review be made of Project Independence, a proposed series of plans and goals to insure achievement of a national goal of energy "self-sufficiency."

In accordance with the Committee's request, the results of the review relative to a determination of the factors which have contributed to the rising cost of electricity to the American consumer, the reasonableness of such increases, and the effect environmental regulations promulgated by the Government have had upon the cost of electricity are included in this report.

Respectfully submitted,

C. R. Anderson
Chief of the Surveys and
Investigations Staff
House Appropriations Committee

Energy Survey

David A. Schmidt, Director
Surveys and Investigations Staff
House Appropriations Committee

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SUMMARY AND OBSERVATIONS

Born in the 1880s, the electric utility industry has grown to become the largest industry in the nation. It is reported that Americans use 34 percent of the electricity generated in the world.

The electric power industry, in 1973, consisted of 3,282 systems divided into 4 segments. The investor-owned and dominant segment consisted of some 230 individual utilities serving 49 states and the District of Columbia and accounted for approximately 78 percent of the nation's net generation and sales to ultimate consumers. Some 2,005 non-Federal public systems operated in 48 states, Puerto Rico, and territories of the United States, and accounted for 8.6 percent of the industry's net generation and 12.5 percent of sales to ultimate customers. Electric power generated at approximately 70 Federal projects in the United States is marketed by 6 large Federal agencies (including the Tennessee Valley Authority). This Federal segment accounted for more than 11 percent of the industry's net generation in 1973 and 4 percent of sales to ultimate consumers. Approximately 977 Rural Electrification Administration-financed electric cooperatives operated during 1973 in 46 states and Puerto Rico and accounted for 2 percent of the industry's net generation and 5.5 percent of its sales to ultimate consumers.

Electric utilities, the investor- or privately owned ones particularly, are widely regulated at the Federal and state levels. The most significant Federal regulation of electricity prices is performed by the Federal Power Commission (FPC) which is responsible for approving interstate wholesale electric rates--rates applicable to only about 15 percent of the power sold. Other significant Federal regulations are imposed by the Securities and Exchange Commission, Nuclear Regulatory Commission (NRC), and Environmental Protection Agency (EPA).

Most rate regulation is performed by state regulatory commissions whose responsibilities include approving utilities rate bases (the investment on which firms are permitted to earn "just and reasonable" returns) and rate levels and structures designed to provide determined amounts of income. In general, only investor-owned firms are subject to state rate regulatory activity.

State commissions, in many instances, take more than a year to establish a new set of rates. Furthermore, they have also been described as passive. Until recently, state agencies have usually left the details of rate design to the utilities. The typical American rate design has been one where prices are differentiated by classes of customers (residential, commercial, and industrial) and by the amount of energy taken--the cost of a unit of energy declines with increased energy use. This system produces highest rates for small residential users, lowest for large industrial customers.

Regulatory commissions are required to approve rates on a cost basis. The price a consumer pays for power should equal the cost of service plus a reasonable profit. There is considerable debate, however, on whether the declining block rate structure, just described, fairly allocates costs. Regulatory officials admit that all rates may not be fairly imposed and that one class or group of customers may be subsidizing another. One Massachusetts state official pointed to a rate structure that failed to allow a utility to recover costs from large users. Such a pernicious rate structure (1) forces small customers to subsidize large users, (2) encourages large users to increase usage because of lower rates, and (3) causes the utility to add costly capacity, thereby increasing all rates.

One promising approach to rate design improvement is peak load pricing. This concept is derived from the need for a utility to build capacity for its

peak demand periods and allow that capacity to sit idle much of the time. The argument is that those who use power in the peak period should pay a premium rate.

Peak load pricing has the support of economists, consumer-oriented energy experts, and many regulators. The FPC chairman has recognized it as being of "greatest importance." The Investigative Staff found no other approach which promises as much immediate and long-term relief to consumers and utilities alike. Besides making rates more economically rational, peak load pricing would have the supplementary benefit of making utilities more efficient, slowing peak demand growth, and deferring capacity construction. Major opposition to peak load pricing comes from the utility industry which claims that the added metering costs make implementation of the concept impractical. Some experts, however, contend that recent technical advances make time-of-day metering practical and point out that peak load pricing has been used successfully for years in other countries.

The presence of automatic fuel adjustment clauses in rate schedules has recently provoked controversy. The clause operates to raise rates without benefit of a formal ratemaking procedure; and opponents claim it removes the economic incentive to bargain hard for fuel, may distort management investment decisions, and insulates firms from the normal risks of doing business. The utilities and regulators observe that operation of such clauses protects a firm's income during times of rapid fuel cost inflation and lessens the administrative burdens on regulatory bodies. Such a clause has been found illegal in some states since it violates the traditional requirement for a formal ratemaking procedure when a significant rate increase is under consideration.

At the Federal level, the FPC is the source of a variety of financial and operating data on the electric power industry. FPC's annual data publications, however, are notoriously untimely, running over a year late. FPC's tardy reporting has caused duplicative efforts in other Federal agencies, and has led industry and regulatory spokesmen to note that these publications have value mainly as historical documents. For example, FPC's belated reporting forced the Investigative Staff for the purposes of this study to rely on limited, manually compiled current data.

FPC data show that, after increasing slightly in the early 1970s, the cost of electricity rose almost 23 percent over the previous year during the 12 months which ended in September 1974. Average consumer cost per kilowatt-hour (kwh) was 33 percent higher in September 1974 than in September 1973. Regional data show average cost increases of from 20 percent to almost 50 percent

Costs of fuel, capital, facilities, and environmental controls have been identified as the significant, immediate causes for the recent increases in electric rates.

While the cost of oil has risen most spectacularly--some 3 or 4 times--prices utilities pay for coal, natural gas, and uranium have also risen significantly. Those utilities relying heavily on oil (especially those in the New England, Middle Atlantic, and Pacific Regions) have been hardest hit by fuel price increases; those using mainly natural gas have been most insulated from higher fuel costs.

The electric utility industry is highly capital intensive--increases in the cost of money and of facilities, therefore, hit particularly hard. During 1974 interest rates were high, and the industry cancelled a number of expansion projects for financial reasons. Since the 1960s the cost per kilowatt capacity for

nuclear facilities has risen from $125 to $400 and is expected to rise above $750 by the 1980s. The costs for constructing fossil fuel plants have risen, but not as dramatically, and are expected to continue upward for the remainder of this decade.

EPA and other regulatory agencies claim that the Clean Air Act and the Water Pollution Control Act thus far have had relatively minor national impacts on electricity prices. For example, it is estimated that in 1974 environmentally imposed charges totalled about 25 cents a month for a 750-kwh user in Illinois. (Costs to customers of a specific company, however, vary considerably from the national average.) Most costs associated with these 2 Acts will be felt in the future. A private firm has estimated that total air and water pollution control costs will increase power charges for the average residential user by $1.04 to $2.11 a month by 1983; Federal agencies estimate the cost increase will be about $1.25 per month. While the costs of the items just discussed are largely beyond the control of utilities, there are other factors--more within industry control--which also tend to raise electricity prices. Neither fossil fuel nor nuclear generation facilities are meeting their design capacity and availability expectations. One consultant has estimated that unreliable equipment has raised consumer prices 5 to 10 percent. Additionally, the industry's inefficient use of its capacity further contributes to high prices.

The reasonableness of recent electricity price increases is largely dependent on one's viewpoint. Consumers, long used to stable electricity prices, see the increases as unreasonable. The industry, citing its financial problems, notes that, if anything, rates are too low. The regulators view rates they have approved as generally reasonable.

Industry spokesmen cited several actions designed to hold down prices. Included in these were attempts to promote conservation. The Investigative Staff observed, however, that with the industry's pervasive desire to continue historic growth rates (doubling output about every decade) and with the industry's recognition that conservation of power can eat up profits, there is little real incentive for the industry to promote effective conservation.

One industry spokesman estimated that the future holds significantly higher use of electricity at much higher prices. His only suggestion for keeping prices down was strict environmental accounting. The Federal Energy Administration (FEA), however, estimates that environmental regulations will contribute only 7 percent of a 42 percent projected increase in the price of electricity in the next 8 years.

The industry's past efforts to keep prices down clearly have been ineffective from a consumer's viewpoint. It does not seem that the future holds much hope either, especially so long as the industry's main response to higher costs is simply to raise rates. New approaches to making and selling electricity are needed to help keep the price of power down.

The lack of good cost-benefit analyses and the absence of a clear, comprehensive national energy policy make evaluation of environmental regulations less precise and less relevant than one would wish.

The clean air standards promulgated or approved by EPA have affected the source and supply of electricity. Air regulations have played an important part in some utilities' switch to low sulphur fuels, especially oil. State emission limitations, approved by EPA, are a significant cause of the clean fuels deficit which EPA is now trying to reduce.

From a cost point of view, the EPA guidelines requiring no thermal discharge

from most plants after January 1974 are the most significant result of the Water Pollution Control Act. Industry spokesmen state that the requirements are overly strict and that the costs vastly outweigh the benefits.

EPA estimates that implementation of present air and water quality standards will impose an energy penalty equivalent to almost 200,000 barrels of oil a day in 1983. Neither EPA nor FEA regards this penalty as overly severe.

Licenses and permits for operation of nuclear power facilities are granted by the Nuclear Regulatory Commission (NRC). Although the time associated with reviews conducted by NRC has been reduced since 1970, industry representatives believe that elimination of redundant procedures, hearings, and clearances could reduce even further the construction time and expenses associated with nuclear reactors. Industry spokesmen indicate that nuclear power is considerably cheaper than nonnuclear power, but this assertion is not supported by FPC officials.

Officials at FPC claim that the requirements of the National Environmental Policy Act have significantly delayed construction of needed energy facilities but could provide no data to support their statements. One Federal analysis did conclude that environmental delays occasioned by implementation of this Act, while costly, have not been of the magnitude claimed by FPC or industry representatives.

Utility spokesmen have decried the expense and delay associated with specific environmental requirements, but they cite as a more pervasive ill effect of the regulatory system under which they operate the numerous regulations, overlaps, redundancies, and sometimes conflicting approaches among Federal agencies and between Federal and non-Federal agencies which make long-term planning most difficult. They strongly believe that such conflicts and

consequent uncertainties could be substantially reduced by adoption of an effective, comprehensive, long-term national energy policy.

There is unanimity among representatives of consumer groups, industry representatives, and regulators that Americans can never again expect to return to pre-1973 electricity prices--the future is indeed bleak. The chairman of FPC recently made several proposals designed to ease the financial plight of the industry. In general, implementing these suggestions would effectively raise the price of electricity and, thereby, lessen the financial strain on utilities. The suggestions, however, contain little that could be interpreted as redounding to the direct financial benefit of the consumer.

Implementation of the President's recently announced energy program will cause the price of electricity to rise. An FEA estimate of proposals to place an import fee on crude oil, to tax and deregulate all domestically produced petroleum, and to deregulate new natural gas is that implementation of the program will cause an average 6 percent increase in power bills over that which will occur without implementation of the program. This estimate, however, is low and misleading. For example, the assumption of the FEA analysis that coal prices will be unaffected by the program is unrealistic. Many experts believe that the Administration's program will increase coal demand and its price, and encourage attempts to price coal on an energy content basis equivalent to oil. Further, the FEA analysis did not consider regulatory changes which will be proposed to state commissions. Even assuming that coal prices remain steady, but that state regulatory commissions and the FPC act on the Administration's proposals, electricity prices, on the average, could rise at least 14 percent during the program's first year.

I. INTRODUCTION

A. Directive

By directive dated August 20, 1974, the Committee requested that a review be made of Project Independence, a proposed series of plans and goals to insure achievement of a national goal of energy "self-sufficiency," to include, but not be limited to, the following:

(1) A determination of the factors which have contributed to the rising cost of electricity to the American consumer and the reasonableness of such increases.

(2) A determination of the possibility and practicality of achieving Project Independence's announced goal of energy self-sufficiency, an analysis of efforts undertaken to conserve existing energy sources and develop new energy sources, and a determination of the United States' capability to effectively address future energy crises.

(3) A review of the effect environmental regulations promulgated by Government agencies have had upon the supply and source of energy.

(4) A determination of the cost attendant with achieving energy self-sufficiency.

B. Scope of Inquiry

At Washington, D.C., the Investigative Staff interviewed appropriate management, fiscal, and policy planning officials affiliated with the headquarters offices of the Federal Energy Administration, Federal Power Commission, and Environmental Protection Agency, and representatives of the Office of Consumer Affairs, Department of Health, Education, and Welfare, and the Congressional Research Service of the Library of Congress.

Interviews were also conducted at Washington, D.C., with representatives of such electric utilities interest groups as the National Association of Electric Companies, the American Public Power Association, and the Energy Research Group (an organization representing 13 large investor-owned electric utilities located throughout the United States), and various consultants experienced in the energy field.

The Investigative Staff reviewed pertinent legislative acts, and regulations, guidelines, studies, reports, and other data promulgated by the headquarters offices of the aforementioned Federal agencies.

In addition, to further develop the information requested in the Committee's directive, the Investigative Staff visited the States of California, Florida, Illinois, Massachusetts, and New York where officials and/or staff members representing state regulatory agencies, public and private consumer organizations, and selected electric utilities furnished comments and material relating to the electric power industry in their respective areas.

II. HISTORICAL PERSPECTIVE

From an infant born in the 1880s, the United States' electric utility industry has grown to be the largest in the nation. Americans now use almost 34 percent of the electrical energy produced in the world.

In the diversity and complexity of its organization, this country's electric utility industry is unique among the power industries of the world. As of December 31, 1973, the industry included approximately 3,282 suppliers, which varied greatly in size, type of ownership, and range of power supply functions.

Basically, the industry is made up of 4 distinct ownership segments--investor- or privately owned companies, non-Federal public agencies or municipals (state and local public agencies), Federal agencies, and cooperatives. Generation and transmission facilities are, as a general rule, economically interdependent in that the choice of location, design, and scale of generating capacity must take into account the associated costs of transmission and vice versa. Responsibilities for generation and transmission customarily go together. Distribution can be, and frequently is, conducted as a separate operation from generation and transmission.

A. Structure of the Electric Power Industry

Information furnished by representatives of the Federal Power Commission (FPC) detailing the composition of the electric power industry in the United States as of December 31, 1973, is shown in the following table and indicates that much of the industry's total volume is handled by a small fraction of the total number.

NUMBER OF ELECTRIC UTILITY SYSTEMS
BY OWNERSHIP CLASSIFICATION, NET GENERATION,
AND SALES TO ULTIMATE CONSUMERS - YEAR 1973

Number	Ownership	Net Generation*	Percent of Total	Sales to Ultimate Consumers*	Percent of Total
230	Investor (Private)	1,444,927	78.1	1,337,062	78.0
2,005	Non-Federal Public (Municipal)	158,290	8.6	214,590	12.5
70	Federal	210,873	11.4	68,228	4.0
977	Cooperative	35,169	1.9	93,500	5.5
3,282	Total	1,849,259	100.0	1,713,380	100.0

* Kilowatt hours in millions.

The types and sizes of systems constituting the electric power industry vary from state to state and from region to region, but most states are served by several types of power suppliers. The State of Mississippi is illustrative. Most customers there are served by 2 major investor-owned utilities. There are also 27 municipals or non-Federal public systems and 25 electric cooperatives. Too, the Tennessee Valley Authority sells power at wholesale to a number of the municipals and cooperatives within Mississippi.

1. Investor-Owned (Private) Systems

The investor-owned segment of the electric power industry consists of some 230 individual enterprises in 49 states and the District of Columbia--Nebraska is the only state in which all electric utility service is consumer-owned, that is, provided by either publicly owned or cooperative systems. This is only 7 percent of the approximately 3,282 systems that comprise the total industry. In terms of any index of size, however, such as kilowatt-hours (kwh)

generated or numbers of customers, the investor-owned systems clearly constitute the dominant segment of the industry. During 1973, the privately owned segment accounted for slightly more than 78 percent of the nation's net generation and 78 percent of sales to ultimate consumers.

Included in the total of some 230 investor-owned systems are 217 Classes A and B or major utilities (with annual electric operating revenues of $2.5 million or more, and $1 million or more but less than $2.5 million, respectively) and 13 Classes C and D utilities (those with annual electric operating revenues of from $150,000 to $1 million, and $25,000 to $150,000, respectively). Further, 187 of the 217 total Classes A and B major utilities, nearly all of which operate integrated generation, transmission, and distribution systems, account for 99 percent of the total investor-owned electric utilities' operating revenues reported in annual FPC statistical publications.

The number of ultimate customers served by the privately owned Classes A and B electric utilities in 1973 averaged 61,026,204. Ultimate customers are classified into 3 broad categories--residential, commercial, and industrial. Residential customers, numbering 53,759,712, accounted for 88.1 percent of the total. Definition of the commercial and industrial classifications is based on power demand. Commercial customers, numbering 6,753,829 (or 11.1 percent of the total), are those with demands of less than 1,000 kilowatts. Industrial customers have demands in excess of 1,000 kilowatts and accounted for 295,489 (or .05 percent). Such additional customer classifications as public street and highway lighting, other public authorities, railways and railroads, and interdepartmental users accounted for the remaining 217,174 (or 0.3 percent). Residential, commercial, and industrial customers used about 31, 24, and 41 percent, respectively, of total sales to ultimate customers in 1973.

Coal-, oil-, or gas-fired steam electric generating plants, numbering approximately 676, were the source of 86.7 percent of the total kwh generated by the Classes A and B investor-owned electric utilities in 1973. Twenty-five nuclear plants (5.3 percent), 700 hydroelectric plants (6.2 percent) and 643 internal combustion and gas turbine plants (1.8 percent) accounted for the remaining 13.3 percent.

The investor-owned systems, financed by private equity and bonds, range in size from the largest in the nation (apart from the Tennessee Valley Authority) to some of the very smallest, and generally serve prescribed areas pursuant to territorial franchises granted by state or local government agencies. These franchises are often not exclusive in the technical sense, but under most state laws a second investor-owned company cannot be franchised in a given territory without demonstrating that additional service is required by public convenience and necessity.

The following table indicates the scope of the investor-owned systems' operating revenues, income, and expenses for 12 months ending September 30 during the years 1972 through 1974.

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INVESTOR-OWNED ELECTRIC UTILITIES 1/
OPERATING REVENUES, INCOME, AND EXPENSES

	Twelve Months Ending September 30 1972	1973	1974
Sales of Electric Energy	(kilowatt-hours in millions)		
Sales to Ultimate Customers	1,214,393	1,323,340	1,331,997
Sales for Resale	209,010	228,508	230,322
Total Sales of Electric Energy	1,423,403	1,551,848	1,562,319
Operating Revenues	(dollars in thousands)		
Sales to Ultimate Consumers	$22,389,996	$25,490,391	$30,992,285
Sales for Resale	1,762,597	2,091,271	2,929,598
Other Electric Revenues	362,582	403,126	543,002
Total Operating Revenues	$24,515,175	$27,984,788	$34,464,885
Operating Expenses	(dollars in thousands)		
Salaries and Wages	$ 3,058,381	$ 3,326,867	$ 3,642,935
Fuel Expense	5,224,642	6,329,599	10,186,649
Other Operation and Maintenance Expense	4,131,653	4,780,155	5,765,481
Depreciation Expense	2,594,088	2,896,930	3,244,205
Taxes Other Than Income	2,587,744	2,844,892	3,175,332
Federal and State Income Taxes - Net	1,430,549	1,607,058	1,585,137
Total Operating Expenses	$19,027,057	$21,785,501	$27,599,739
Net Operating Income	$ 5,488,118	$ 6,199,287	$ 6,865,146
Interest Charges	$ 2,901,626	$ 3,365,928	$ 4,217,094
Net Income 2/	$ 4,328,404	$ 4,823,438	$ 5,153,224

1/ 187 investor-owned electric utilities (of 217 Classes A and B reporting) account for 99 percent of total electric operating revenues reported in annual FPC statistical publications.

2/ Net income after nonoperating items not chargeable to consumer (for example, rentals, interest on dividends and investments, allowance for funds used for construction, and extraordinary items) are included.

2. Non-Federal Public Systems

Non-Federal public (or municipal) power systems have been part of America since modern central station electric service was pioneered by Thomas A. Edison in 1882. Several cities have had municipal electric systems for more than 80 years. In the beginning, many towns established their own electric plants to get electric lighting. More recently, other cities have formed municipal utilities in an attempt to provide their citizens with better service and lower rates.

Most non-Federal public electric utilities serve small towns, but a number of large cities--including Los Angeles, Seattle, Memphis, Sacramento, Nashville, and Chattanooga--have their own electric systems.

Municipal power systems have been created in areas other than incorporated cities. Public utility districts or public power districts have been formed in large areas of Washington, Oregon, California, Nebraska, South Dakota, and Arizona. Several county electric systems have been organized in other states. State power agencies also have been set up, usually to take advantage of water power resources. These agencies usually serve largely at wholesale.

The some 2,005 non-Federal public systems now in existence operate in 48 states (there are no municipal electric power systems in Hawaii and Montana), Puerto Rico, the Virgin Islands, Guam, and American Samoa, and during 1973 accounted for 8.6 percent of the industry's total net generation and 12.5 percent of the sales to ultimate consumers. Nebraska, the only state in which all electric utility service is consumer-owned, leads the nation with 167 non-Federal publicly owned utilities. Other leading states in numbers of local public power systems are: Iowa, 145; Kansas, 133; Minnesota, 129; Missouri, 89;

Ohio, 86; Wisconsin, 85; Texas, 77; Indiana, 74, North Carolina, 73; and Oklahoma, 71. In all, 13 states have 50 or more local publicly owned power systems while only 8 states and 4 territories have less than 10.

Of the systems which make up this segment of the industry, about two-thirds are engaged solely in the distribution of electricity purchased from bulk power suppliers; the other one-third operate generating facilities, either as part of an integrated generation-transmission-distribution system or to supply power for distribution by others. These systems purchase approximately 35 percent of their requirements from the Federal systems and an additional 11 percent from investor-owned systems.

Municipal power agencies are exempt from Federal income tax and generally are not subject to state income tax. They are usually exempt from other state and local taxes, but many of them make payments in lieu of taxes to their own local governments and provide power free or at reduced rates for street lighting, water pumping, and other municipal uses.

3. Federal Systems

Six large Federal agencies, representing a total of approximately 70 Federal electric power projects, market federally generated power in the United States: the Tennessee Valley Authority (TVA), Bonneville Power Administration, Southwestern Power Administration, Southeastern Power Administration, Alaska Power Administration, and Bureau of Reclamation. This Federal segment, during 1973, accounted for more than 11 percent of the industry's total net generation and 4 percent of its sales to ultimate consumers.

The TVA, established in 1933 as an independent, federally owned corporation to facilitate development of the resources of the Tennessee River Basin, was authorized initially to develop hydroelectric power resources in conjunction

with navigation and flood control. In the early 1950s, following essentially full development of the hydroelectric power potential of the Basin, TVA began developing a comprehensive power production system by adding fossil-fueled and nuclear generating plants; today approximately 80 percent of its electric generation is from coal-fired steam plants.

While its nonpower activities continue to be supported by appropriated funds, TVA's power program is now a self-supporting and self-liquidating operation, bearing all costs related to power supply. Operating expenses are financed from power revenues; construction costs are financed from both revenues and borrowings.

TVA is the nation's largest electric system, with approximately twice the generating capacity of the next largest; more than half of its power production is sold at wholesale to municipal and cooperative systems, with most of the balance going to industrial customers and Federal agencies.

Power marketed by the 5 other large Federal agencies is hydroelectrically generated and generally supplements the electric power supplies of other systems in the areas in which they operate. The Secretary of the Interior is the marketing agent for power produced by all Federal power projects other than TVA. Except for sales to a number of large industrial customers, nearly all of the power is sold at wholesale to other electric systems.

The Bonneville Power Administration markets the electric power produced at the various Federal hydroelectric projects built and operated either by the U. S. Army Corps of Engineers or the Bureau of Reclamation. It serves the area drained by the Columbia River including the States of Idaho, Montana (west of the Continental Divide), Oregon, Washington, and small adjacent portions of California, Nevada, Utah, and Wyoming. The Bonneville Power Administration

supplies some 55 percent of the power generated in that region and has the capacity to transmit about 80 percent of the region's power.

Multipurpose reservoir projects have been constructed and operated by the Army Corps of Engineers primarily for navigation and flood control; although not a primary objective, hydroelectric power facilities have been installed at such sites to avoid wasting the use of falling water. Any power which is not needed in the operation of these reservoir projects is released to the Secretary of the Interior for disposal "in such manner as to encourage the most widespread use thereof at the lowest possible rates to consumers consistent with sound business principles . . . ." The Southwestern Power Administration, Southeastern Power Administration, and Alaska Power Administration were created by the Secretary of the Interior to discharge this marketing function.

The Southwestern Power Administration, created in 1945, markets power in Missouri, Arkansas, Louisiana, Texas, Oklahoma, and Kansas, and operates and maintains approximately 1,700 miles of high voltage transmission lines. In 1972 it sold 44 percent of its total energy to 41 cooperatives, 21 percent to 37 municipalities, 22 percent to 5 investor-owned utilities, and the remaining 13 percent to military installations and other facilities.

The Southeastern Power Administration, established in 1950, operates in a 10-state area and relies exclusively on transmission arrangements with other systems to market its power to 79 municipalities, 101 cooperatives, 1 state and 1 county agency, 6 privately owned utilities, and TVA.

The Alaska Power Administration was created to market Federal hydroelectric power in the State of Alaska and to discharge a regional planning function. In 1972, 56 percent of the power marketed by the Alaska Power Administration went to the city of Anchorage and the remainder to 2 cooperatives.

The Bureau of Reclamation constructs, operates, and maintains water storage projects for the reclamation of arid and semiarid lands in the western states, and, if consistent with the primary purpose of irrigation, generates and markets hydroelectric power as a related activity in 17 contiguous states west of the Mississippi River. It has constructed transmission facilities to interconnect a number of its own plants, as well as other neighboring systems.

The 6 Federal agencies marketing federally generated power are required to give preference to public entities and cooperatives in the sale of electric power. Since public agencies and cooperative systems are given a statutory preference to purchase the output of Federal projects, the extent of Federal systems development has had a significant impact on the number and power costs of preference customers. Such costs reflect the lower fixed charges on capital investment in Federal projects by virtue of their lower interest costs and the absence of Federal income and other taxes.

4. Cooperative Systems

The rural electrification program was initiated by Executive Order in 1935, and legislation was passed in 1936 which established the Department of Agriculture's Rural Electrification Administration (REA) as a lending agency with management responsibility for a direct loan program to finance qualified cooperative associations for the purpose of providing generation, transmission, and/or distribution of electric power to rural residents not receiving central station service. In 1944 a 2-percent interest rate and a 35-year maximum repayment schedule were prescribed for such REA loans. The 2-percent direct loan program was curtailed in 1973 and, ultimately, new legislation was enacted providing for a 5-percent insured and guaranteed loan program with some direct 2-percent loans available for "hardship" cases.

Approximately 977 REA-financed rural electric service cooperatives (or borrowers) were in operation during 1973 in 46 states and Puerto Rico, and accounted for almost 2 percent of the industry's net generation and 5.5 percent of its sales to ultimate consumers. There are no electric cooperatives in Connecticut, Hawaii, Massachusetts, and Rhode Island.

Of the above cooperatives, 43 operated generation and transmission facilities exclusively; 901 engaged primarily in operating distribution systems; and the remainder were borrowers for consumer facilities. The cooperatives' distribution costs per customer have been relatively high because they serve an average density of only about 4 customers per mile of line. On the other hand, cooperatives have generally avoided the relatively high costs associated with inner-city congestion.

Electric cooperatives purchase approximately 77 percent of their wholesale power requirements--45 percent from the government segments and 32 percent from investor-owned utilities; the remaining 23 percent is self-generated.

While REA-financed cooperatives, like other consumer cooperative ventures, do not operate for profit and, therefore, pay no Federal income tax, they are liable in some instances for state and local property taxes. In some states, they also pay gross revenue taxes, sales taxes, and other state and local taxes.

B. Regulation

Since electric utilities are local monopolies, the electric power industry has been subject to regulation of various of its activities almost since its inception in the late 1800s. Due in large measure to concerns for the reliability of electric power supply and the preservation and protection of the environment, the increasing importance of nuclear power in the total power supply, and the rapidly rising cost of fossil fuel and capital in the context of

a generally inflationary economy, the scope and tempo of regulatory activity have increased during recent years. The following system of significant Federal and state regulation has developed concerning electric utilities' individual and collective operations.

1. Federal

At the Federal level, the Federal Power Commission (FPC), Securities and Exchange Commission (SEC), Nuclear Regulatory Commission (NRC)(whose functions were formerly performed by the U.S. Atomic Energy Commission), and Environmental Protection Agency (EPA), among others, have substantial responsibilities for regulating specific activities of electric power systems.

The FPC exercises national responsibility to provide certain types of economic regulation of investor-owned electric utilities. Its responsibilities include the regulation of interstate wholesale rates and services between investor-owned firms; authority over the rate schedules pursuant to which Federal power is marketed by such constituent agencies of the Department of the Interior as the Bonneville Power Administration, Southwestern Power Administration, Southeastern Power Administration, and the Alaska Power Administration (but not the Bureau of Reclamation, which has no particular type or form of rate dictated by law); the licensing of virtually all non-Federal hydroelectric projects; and the regulation of corporate activities, accounts, and reports of systems subject to its jurisdiction.

It is interesting to note that FPC, in fulfilling its responsibility for regulating interstate wholesale rates, actually controls rates applicable to only about 15 percent of the kwh sold and about 7 percent of the total electric utility revenues produced by the investor-owned segment of the industry.

The SEC has regulatory responsibilities over the electric utility industry as a consequence of the Securities and Exchange Commission Act of 1933 and the Public Utility Holding Company Act of 1935. Under the latter, the SEC is concerned with the financing of holding companies (those companies which directly or indirectly control 10 percent or more of the outstanding voting securities of a public utility or holding company, or which, in the judgment of the SEC, can exercise a sufficient influence over such an entity as to make regulation appropriate) and with their acquisition of other entities. The 1935 Act authorizes the SEC to regulate utility holding companies to prevent or eliminate large, complex systems that could circumvent regulation, concentrate political power, and create economically unstable corporate structures. Such phases of the activities of public utility holding companies and their subsidiaries as accounting, security issuances, mergers, service company arrangements, and intercompany transactions receive regulatory attention by the SEC.

The Atomic Energy Act of 1954 authorized the Atomic Energy Commission (whose regulatory functions have recently been assumed by the Nuclear Regulatory Commission) to regulate construction and operation of all nuclear reactors regardless of their type of ownership. This regulation provides for significant involvement in the electric power industry since the advent and large-scale use of nuclear energy is probably the most important single change in the industry during the past 50 years.

EPA was created in December 1970 with the mandate to mount an integrated, coordinated attack on environmental pollution in cooperation with state and local governments. As a regulatory agency, EPA is required by law to approve or establish and enforce certain environmental standards for pollution control. Its responsibilities encompass a range of environmental concerns, but

the focus here is on standard-setting and enforcement in 2 of EPA's programs--air and water pollution control.

Standards define what may or may not be put into the air and water based on the best available scientific knowledge. They place limits on the pollutants that can be tolerated without endangering the health and welfare of human beings and of the ecological systems in which we live.

The standards set by EPA, in some cases in cooperation with the states, have the force of law. EPA shares enforcement of some standards with the states, with the Federal Government acting only if a state fails to do so. In some instances, the Federal Government has primary responsibility for enforcing standards.

The Clean Air Act Amendments of 1970 authorized EPA to establish national ambient air (the outdoor air round us) quality standards for pollutants and required the states to adopt implementation plans to meet those standards. EPA has issued national air quality standards for the 6 most common pollutants--sulfur oxides, particulates, carbon monoxide, photochemical oxidants, hydrocarbons, and nitrogen oxides--and is studying other pollutants to determine if additional national air quality standards are needed.

The national standards established by EPA are in 2 parts, primary and secondary. A primary standard is designed to protect public health and sets a limit on the amount of a pollutant in the ambient air that is safe for humans. A secondary standard is designed to protect public welfare, is usually more stringent than a primary standard, and sets a limit on the amount of a pollutant that is safe for clothes, buildings, metals, vegetation, crops, animals, and the like.

The Water Pollution Control Act Amendments of 1972 established a national program to combat water pollution and, for the first time, extended the national program to all navigable water bodies in the United States. The Act also created a system of national effluent limitations (the maximum amounts of a pollutant a source may discharge into a water body) and national performance standards for a variety of industries, including steam electric power plants.

Limiting emissions from existing factories and plants is only part of the air and water pollution control problems. Another objective is to control emissions and reduce effluent discharges from new industrial sources (new plants and factories and old plants that, when modified, produce greater emissions and discharges) of air and water pollution. Such performance standards are based on the degree of emission and effluent limitations that can be achieved by using the best available demonstrated control technology, processes, operating methods, or other alternatives, taking into account the cost of the control system, energy requirements, and the environmental impact of the standards. EPA has so far issued Federal air and water pollution performance standards for a variety of new facilities, including fossil-fueled steam generating plants (those that use coal, oil, or natural gas as fuel).

2. State

Since the early part of this century, major responsibility for the regulation of the electric power industry, especially the investor-owned segment, has rested with the state utility commissions. At the present time, commissions with authority to regulate the retail rates (which account for approximately 93 percent of the electric utility revenues produced by privately operated systems), rates of return, and rate structures of investor-owned electric utilities operating within their boundaries exist in 47 states, the

District of Columbia, and Puerto Rico. The exceptions are Nebraska, Texas, and South Dakota; in these states various forms of local regulation are authorized.

State utility commissions do not have authority over federally operated electric power facilities and relatively few state commissions control the rates of municipally and cooperatively owned utilities. Of the 47 state commissions vested with authority to regulate privately owned electric utility rates, only 16 have similar authority over publicly owned and 25 over cooperatively owned electric utilities.

The scope of the authority of state commissions to regulate electric utility systems varies considerably among the states; but many state commissions have rather broad powers, including the regulation of rates, accounting, security issues, safety, and adequacy of service, as well as authority for certification of major property additions, initiation and abandonment of service, and allocation of territory.

At the state level, too, the increasing public concern for the quality of the environment has been evidenced by the actions of state legislatures in recent years to strengthen the role of the state regulatory commissions and other state agencies in controlling the environmental effects of electric power facilities.

C. Rate Base and Rates

From the viewpoints of consumers and utilities alike, one important aspect of Federal and state electric utility regulation is the authority of regulatory commissions to establish how much money a firm will be permitted to earn. Although there are some variations, Federal and state commissions follow similar procedures.

Typically, a rate proceeding is initiated by the utility. The utility

requesting a rate change files with a commission its statement of net investment, that is, the rate base, on which the firm desires to earn a certain return. It is the duty of the appropriate commission to first determine that the applicant's statements are accurate and justified and then to establish a permitted rate of return on the rate base. By statute, the rate of return must be "just and reasonable" and permit the utility to provide reliable service from prudent investments.

During these phases of regulation, the applicant, the commission, and, often, interested representatives of the public, present exhibits and witnesses in public hearings. From the time of the initial filing until final disposition of the request may entail a period of from several months to more than one year. In some cases commissions allow a utility's proposal to become effective prior to final processing subject to customer refund (should the commission find the proposal excessive) after final disposition of the rate proceeding.

After a regulatory commission has established the utility's rate base and permitted rate of return, it must approve a level and structure of rates designed to produce the required revenues. Statutorily, rates are required to be nondiscriminatory--the price a customer pays must equal the cost of serving him. It has been said that, until fairly recently, regulatory commissions have been passive in this respect and have left rate design largely to the discretion of the utilities. More and more, however, commissions are actively challenging proposed rate structures and there is, generally, increased interest in the impact of various rate structures.

Historically, electric rates in the United States have been differentiated by classes of customers and the amount of power consumed. The residential class typically pays bills based on a declining block rate structure. Electricity is sold in blocks of kwh, with successive blocks having lower unit costs. The more

electricity a residential consumer uses, the lower the average kwh cost.

For larger commercial and industrial customers, declining block energy rates are often coupled with a power demand charge designed to take into account generating capacity that the user's peak demand requires. Under such an energy-demand tariff, customers are rewarded for the nonerratic use of electricity, and large industrial users have the lowest retail rates in the entire rate structure.

The traditional justification for declining block rates is that a utility must pay fixed costs even if a customer takes no electricity. The higher initial blocks are designed to recover such costs; the low unit costs for the last blocks of power theoretically cover only the variable costs of producing electricity.

Although rate structure has recently become a topic of widespread interest, there is little agreement on whether present rate structures are equitable or economically justified. Even the regulatory commissions, which have the ultimate responsibility for approving rate structures, admit that some customers might be subsidizing others. All the regulatory commissions contacted by the Investigative Staff claim to be now actively studying this most complex question.

From the industry's point of view, rate structure is important because it helps determine how much power a customer will take. Generally, the Investigative Staff found, regulatory commissions recently have not permitted rate blocks (as opposed to price) to decline as steeply as the utilities had originally requested. To the degree that consumption is responsive to price, such rate flattening will lower the amount of power used, retard the growth rate of utilities, or both. It appears that utilities generally favor declining rates over flatter ones and that this is partially attributable to management's desire

to encourage company growth.

Except for those who press for such social objectives as cheap electricity for the poor, consumer advocates agree in principle with the utilities and regulatory agencies that consumer costs should be fairly allocated to preclude one consumer subsidizing another. Public advocates argue, however, that costs are not being equitably shared by different types of customers, that regulatory agencies have condoned utility rates designed to promote consumption, and that the utilities' cost allocation methods and assumptions are often unrealistic and inadequate. To illustrate, one state consumer agency official discussed a rate schedule effective in his jurisdiction which does not permit a utility to recover costs from serving its large electric energy users. This discriminates against other users who are forced to pay more than their fair share, promotes uneconomic consumption and utility expansion, and, since the cost of producing power is rising, eventually causes higher prices for all customers served by that utility.

In their efforts to define more equitable rate structures, consumer-oriented groups advocate several other approaches. One is peak load pricing, which receives widespread support, has strong grounding in economic theory, and is also favored by groups not especially consumer-oriented. In simple terms, this device involves charging more for electricity sold during times when a utility must approach capacity generation and less at other times. Proponents argue that it costs more to produce electricity during the peak periods because so much capacity has to be built which is used only in the peaks; therefore, pricing power on a true cost-of-service basis should result in higher rates in the peak.

Although peak load pricing could be expected to increase the efficiency of utilities--they would need less capacity and could utilize it more fully--and although it has been successfully used in other countries, including England, France, and Japan, the Investigative Staff found utility representatives resistant to serious consideration of this approach because of the claimed higher costs associated with the more sophisticated time-of-day metering which would be required. Too, one Federal regulatory official impatiently dismissed peak load pricing as merely "a gimmick which looked the wrong way"; instead of using price as a means of allocating electricity, he favored expanded growth.

But would such time-of-day metering be cost justified? Is peak pricing "a gimmick"?

Some utility pricing experts contend there is evidence already available which indicates that recent technical developments have brought the cost of the more sophisticated metering, which would be required, within the range where it becomes economically feasible to institute time-differentiated pricing. Further, anticipated expenditures for new capacity are of such magnitude for U.S. electric utilities that even modest gains from reductions in capacity requirements would free those funds for investment in a metering network many times more costly than existing equipment.

Obviously, the current chairman of the FPC does not consider peak load pricing a gimmick. Before a meeting of state regulatory commissioners and Federal officials in Washington, D.C., on September 11, 1974, he said:

> "Probably of greatest importance in our attempts to rationalize electricity pricing is the concept of peak load responsibility. Electric utility management should explore the possibilities of time-of-day metering and peak load pricing. Economic incentives to consume electricity off peak would reduce consumer charges. Capacity expansion would be slowed

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> with proportional savings in investment costs. Seasonal differential rates are modest steps in this direction but the ingenuity of the executives of this industry can surely devise more imaginative schemes that will slow growth in peak demand and defer capacity construction."

Some consumer-oriented groups favor inverted, or rising, block rates. Devotees of this approach argue that, since the costs of producing power are no longer declining, as they were until the late 1960s, those who cause growth should pay the price. Inverted rates, however, have received little support from either utilities or regulatory agencies. They contend that since all categories of consumers are causing increased use of power, it would be unfair to impute cause of growth to either new customers or large users.

A variation of the inverted block rate is the lifeline rate, where a certain small amount of power would be provided below cost either to the poor or to all consumers. The lifeline rate would involve redistributing money from high to low users and cannot be justified on purely cost allocative grounds; it is, therefore, generally beyond the jurisdiction of regulatory commissions which are statutorily required to approve rates on a cost basis.

Of all the facets of rate design, probably the one most subject to recent popular controversy is the automatic fuel adjustment clause. Basically, the automatic fuel adjustment clause allows utilities to pass on fuel costs to customers without the process of a formal rate-making. As fuel costs rise, a monthly or bimonthly charge is assessed on a flat per kwh basis, resulting in relatively greater cost increases for large users who previously were paying lower unit costs. Conversely, when fuel costs decline, a largely academic concern at present, the clause operates to lower bills automatically.

Obviously, utilities would be most anxious to have such automatic

pass-throughs in their rate schedules during times of rising prices but less enamored with the concomitant responsibility of lowering rates automatically to coincide with declining fuel costs. Though improper motives were denied at the time, the New England Power Company, for instance, filed for removal of its fuel adjustment clause in 1968 when its fuel costs were declining. In 1970, however, when its fuel costs were running the other way, the company filed to reintroduce a fuel adjustment clause.

The fuel adjustment clause has been present in commercial and industrial rate schedules since the early twentieth century and, since the 1950s, has been increasingly applied to residential rates as well. In 1970 about 35 percent of the investor-owned utilities serving cities of over 25,000 had automatic fuel adjustment provisions in their residential rate schedules; by 1974 this number had risen to 72 percent. Comparable data for industrial rates show an increase from 72 percent to 83 percent. In November 1974 approximately 37 states had automatic fuel adjustment clauses.

Proponents of the automatic fuel adjustment clause claim such a provision eases regulatory commissions' administrative burdens, protects utilities' income during times of rapidly increasing fuel costs, and redounds to the consumers' benefit when fuel costs fall. It seems clear that the clause can produce such benefits.

Opponents, however, insist that the clause removes the economic incentive for utilities to bargain with fuel suppliers as hard as they might otherwise, may distort management decisions since a company might opt for a fuel-intensive solution to a problem when another tactic would have been more appropriate, may encourage and subsidize inefficiency by insulating a company from the normal tribulations and risks of doing business, and may even be illegal.

Theoretically, it is clear that the automatic fuel adjustment clause does remove the economic incentive for hard bargaining and could distort management decisions. It is extremely difficult, however, to identify utility activities which could be construed as support for such charges. For example, utility representatives indicate their companies are paying for fuel about what neighboring utilities are paying and argue this is evidence that hard price bargaining is, in fact, taking place. Such an argument, of course, proves little or nothing, except perhaps that neighboring utilities are acting alike. But such reasoning shows the difficulty of making comparisons to prove the point one way or the other. Too, there is evidence that some fuel suppliers have overcharged utilities. Had these utilities not had the protection afforded by the fuel adjustment clause, would they have been more diligent in their searches for cheaper fuel? Unfortunately, the answer is not known.

There are other factors operating which may tend to restore some of the incentive removed by application of the automatic fuel adjustment clause. One is inherent in the lag which a company experiences in passing on rising fuel costs. A utility does not pass through fuel costs immediately but generally takes from 1 to 3 months after such costs are incurred to effect the change. In a time of rapidly increasing fuel costs, such a lag means that the utility does not recover all of its increased fuel costs; hence, the economic incentive to bargain may remain.

Secondly, opponents of the automatic fuel adjustment clause may be focusing too narrowly on the clause itself. If there is one consistent impression the Investigative Staff obtained from dealings with utility representatives, it is that they strongly desire continued growth of the industry. To the extent that higher fuel costs raise rates and retard consumption, it is in the company's perceived interest to keep costs down.

Most state regulatory commissions are required to hold formal hearings and rate-making procedures before establishing significantly higher utility rates. In several states, the automatic fuel adjustment clause recently has been found illegal on grounds that it violates this statutory requirement.

III. RECENT ELECTRICITY COST TRENDS

The FPC exercises responsibility for publishing a variety of statistical reports concerning the electric power industry, including such "annual" publications as "Statistics of Privately Owned Electric Utilities in the United States" and "Statistics of Publicly Owned Electric Utilities in the United States." These publications reportedly are intended to give impartial comprehensive financial and operating information on the investor-owned, non-Federal public, and Federal segments of the industry to consumers, assist state regulatory agencies, and provide information concerning individual utilities on a comparable basis.

A. Untimely Federal Reporting

As of February 1, 1975, the FPC, because of claimed shortages in staff and computer availability, had yet to publish the 1973 editions of the aforementioned reports. Consequently, the Investigative Staff's original requests for current comprehensive financial and operating information on privately and publicly owned electric utilities were met with some agency resistance and delay. The Investigative Staff had to insist that the most current data obtainable be compiled manually and made available.

FPC officials were finally able to supply general national data on the investor-owned (albeit dominant and representative of industry-wide trends) segment of the industry, and, unless otherwise indicated, such information is used throughout this report. The Investigative Staff also attempted to obtain current comprehensive regional information, but FPC was able to furnish information on only 4 of its 9 regions.

The belated availability of the 1973 editions of "Statistics of Privately Owned Electric Utilities in the United States" and its companion publication, "Statistics of Publicly Owned Electric Utilities in the United States," might be more aggravated than usual but certainly not unique. The same publications for 1972 were not printed until December 1973. A question naturally follows as to how useful to the electric power industry, Federal and state agencies, and consumers can such far-from-timely material be.

One FPC official acknowledged that his agency's belated "annual" statistical overviews of the privately and publicly owned segments of the electric power industry do, indeed, lack currency and, as a consequence, aside from historical value, fall short of their intent. A spokesman for the Federal Energy Administration (FEA) expressed similar dissatisfaction with the timeliness of such FPC publications and indicated that his own agency has been compelled on occasion to compile more up-to-date statistics relative to electric utilities to stay abreast of developments in this particularly dynamic industry. He volunteered the comment, "I would not have to exist if FPC was doing its job." State regulatory officials throughout the United States, too, voiced varying degrees of disenchantment with the value accruing to them from such tardy reporting of national electric utility trends.

B. Increased Cost of Electricity

Since the Autumn of 1973, Americans have experienced dramatic increases in the cost of electricity. The price for a kwh of electricity produced by the investor-owned utilities fell slightly in the 1960s; from 1970 until late 1973 the cost rose about 4 percent annually for residential, 6 percent for commercial, and 7.5 percent for industrial customers. For the 12 months ending in September 1974 (which, of course, includes the period of and the months that

followed the energy crisis occasioned by Arab oil-producing nations cutting off exports to the United States), investor-owned utility revenues per kwh rose 22.8 percent over the previous year. Not all of this increase was a result of new rates set by regulatory agencies. Industry-wide, electric rate increases, not including automatic fuel adjustments, averaged about 10 percent during the second quarter of 1974 and 8.5 percent during the 12 months ending June 1974.

The following tabular data represents operating revenue and expense trends per kwh for the investor-owned segment of the electric utility industry for 12-month periods ending September 30 during the years 1972 through 1974:

OPERATING REVENUES AND EXPENSES PER KILOWATT-HOUR WITH PERCENTAGE CHANGES, FOR INVESTOR-OWNED UTILITIES 1/

	Twelve Months Ending September 30				
	1972	1973		1974	
	Cents per Kwh	Cents per Kwh	Percent of Change	Cents per Kwh	Percent of Change
Operating Revenues					
Sales to Ultimate Customers	1.84	1.93	4.9	2.32	20.2
Sales for Resale	.84	.92	9.5	1.27	38.0
Total Sales (Weighted)	1.72	1.80	4.7	2.21	22.8
Operating Expenses					
Salaries and Wages	.21	.21	-	.23	9.5
Fuel Expense	.37	.41	10.8	.65	58.5
Other Operation and Maintenance Expense	.29	.31	6.9	.37	19.4
Depreciation Expense	.18	.19	5.6	.21	10.5
Taxes Other Than Income	.18	.18	-	.20	11.1
Federal and State Income Taxes - Net	.10	.10	-	.10	-
Total Operating Expenses	1.33	1.40	5.3	1.76	25.7
Net Operating Income	.39	.40	2.6	.45	12.5
Interest Charges	.20	.22	10.0	.27	22.7
Net Income 2/	.30	.31	3.3	.33	6.5

1/ 187 investor-owned electric utilities (of 217 Classes A and B reporting) account for 99 percent of total electric operating revenues reported in annual FPC statistical publications.

2/ Net income after nonoperating items not chargeable to consumer (for example, rentals, interest on dividends and investments, allowance for funds used for construction, and extraordinary items) are included.

As indicated in the previous schedule, the price of power to ultimate customers during the 12 months ending September 30, 1974, was up 20.2 percent. Even more dramatically, however, the same cost was up almost 33 percent for September 1974 compared to September 1973 (the month immediately preceding the Arab countries' oil embargo). The data below show revenue per kwh produced by the various classes of ultimate customers served by the Classes A and B investor-owned utilities during September 1973 and 1974:

OPERATING REVENUES OF CLASSES A AND B ELECTRIC UTILITIES

Customer Class	Cents per Kilowatt-Hour September 1973	September 1974	Percent Increase
Residential	2.56	3.27	27.7
Commercial	2.40	3.18	32.5
Industrial	1.27	1.85	45.7
Weighted Average	2.01	2.67	32.8

While these figures indicate the national trend of rising prices for electricity, they mask significant regional variations in price and rates of increase. This is reflected in the table below which represents data from 4 of FPC's 9 regions:

REGIONAL INVESTOR-OWNED ELECTRIC OPERATING REVENUES

Region 1/	Cents per Kilowatt-Hour July 1973	July 1974	Percent Increase
New England	2.65	3.96	49.4
Middle Atlantic	2.59	3.79	46.3
South Atlantic	1.84	2.59	40.8
West South Central	1.55	1.86	20.0

1/ See Appendix I for state composition of FPC regions.

Additionally, the Investigative Staff gathered similar information in California and Illinois (the Pacific and East North Central Regions, respectively). Rates for an average residential consumer in San Francisco (300 kwh,

January 1973 versus November 1974) rose 20.2 percent, from 2.47 to 2.97 cents per kwh. Comparable Long Beach, California, figures are 48.8 percent, and 3.34 4.97 cents. An Illinois Commerce Commission official revealed that rates in that state were up about 20 percent in 1974.

These data, besides showing regional variation in the amount of cost increases, also point up historical regional price differentials. Since 1960, according to data maintained by FPC, the lowest bills for all customer classifications generally have been in the East South Central Region, which benefits from lower cost TVA power, and in the contiguous Pacific Region, which has the cost advantage of hydroelectric power produced by the Bonneville Power Administration and other agencies. For the same period, the highest bills have typically been found in the New England and Middle Atlantic Regions. The costs of fuel, taxes, construction, and labor, one FPC official noted, traditionally have been higher in these regions.

While electric bills have risen dramatically over the past year, the rate of increase in power consumption has declined. In September 1974 the number of customers of Classes A and B investor-owned utilities increased 2.2 percent over the previous September; for the 12 months ending in September 1974, however, consumption was up only 0.6 percent. This increase compares with an average annual growth rate for the electric power industry of about 7.2 percent in the previous decade.

To many customers it was mysterious, if not sinister, that their electric bills were rising while they reduced consumption or tried to keep it constant. What caused these dramatic increases? Why did some customers' bills rise faster than others?

IV. FACTORS CONTRIBUTING TO RISING ELECTRICITY COSTS

As noted in Chapter II, regulation of an electric utility is designed to permit the firm's recovery of costs plus a fair return on investment. Since rates charged by the companies must be approved by regulatory agencies, a process often taking a year or longer, cost increases are not immediately charged to the consumer. The notable exception to this rule is, of course, the automatic fuel adjustment charge, which is usually passed on to the customer in 1 to 3 months.

Utility regulators, industry spokesmen, and/or consumer advocates identified fuel costs, capital and facilities costs, and environmental costs as the most significant and quantifiable factors which have led to recent increases in the price of electricity to the consumer.

A. Fuel Costs

Electricity is a secondary energy form. It is generated by "burning" primary energy matter--petroleum, natural gas, coal, or uranium--or by falling water. Almost without exception the most significant cause of recent increases in electric bills has been the steep rise in the prices of primary fossil fuels (oil, coal, and natural gas).

Although more recent data are not available, information made available by FPC and set out below indicates the portion of power bill increases attributable to higher fuel prices (February 1974) ranged from approximately 32 percent to 96 percent in 10 selected cities.

PERCENTAGES OF INCREASE IN BILLS FOR 500 KWH OF RESIDENTIAL SERVICE ATTRIBUTABLE TO OPERATION OF FUEL ADJUSTMENT CLAUSES IN 10 SELECTED CITIES, FEBRUARY 1973 TO FEBRUARY 1974

City	Percentage Increase in Bill	Percentage of Increase Attributable to Fuel Adjustment Clauses
Boston	24.9	67.5
New York	47.5	74.6
Philadelphia	13.1	49.1
Washington	16.1	68.2
Atlanta	17.0	32.1
Chicago	5.3	40.9
Houston	6.7	40.2
San Francisco	16.4	95.6
Los Angeles	27.7	38.5
Long Beach (California)	36.3	46.6

(While fuel costs have so far provided a major element in rising prices, one may expect the relative impact of fuel costs to decline as utilities are granted rate increases to compensate for increased costs of items not subject to automatic pass-throughs.)

Part of the cost increases have resulted from a proportionate shift to what are now the more expensive fuels. Price differentials which no longer hold true, as well as environmental regulations, have been largely responsible for the change in fuel mix. In the 5 years before 1974, coal declined from 47 to 44 percent of generating fuel input; gas fell from 24 to 20 percent; hydroelectric power from 17 to 15 percent. Oil-fired generation rose from 11 to 17 percent, and nuclear power's share climbed from 1 to 4 percent. Preliminary data indicate that the proportion of coal and hydro power may have increased in 1974.

As with overall generation costs, the national fuel-mix figures hide important regional differences. In New England (for 12 months ending September 1974), 85.8 percent of fossil fuel input was from oil while the East North Central Region relied on coal for 92.1 percent of its fossil fuel generation.

The West South Central Region depended on gas for about 89 percent of its fossil fuel generation. In general, coal was dominant in 6 regions, oil in 2, gas in 1.

The nonfossil "fuels," water and uranium, show considerable regional variation also. Nationally, about 21 percent of our power comes from other than fossil fuels--from 65 percent in the Pacific Region to 2 percent in the West South Central area. In other regions, nonfossil fuel generation accounts for 12 to 28 percent of total generation.

All fuel prices paid by utilities have risen substantially. Coal prices began increasing rapidly in 1972 and exhibit wide regional variation. Oil prices per million British thermal units 1/ rose from 32 to 60 cents from 1969 to 1972 and climbed even more rapidly after that period; there is slight regional variation in these prices. While not so volatile as coal or oil prices, the cost of natural gas also rose in the years after 1969 with considerable regional differences primarily due to transportation costs. Uranium prices were in the $7- to $8-a-pound range until early 1974; by November 1974, prices were up to almost $15 a pound. The fuel cost for nuclear generation, however, is a small part of total costs. A doubling of the price of nuclear fuel has a small impact on total generation expense.

The following table shows changes in fossil fuel prices paid by utilities in a recent 12-month period:

1/ A British thermal unit (Btu) is the amount of heat required to raise 1 pound of water 1 degree Farenheit. Depending on the type and efficiency of a generating facility, 1 million British thermal units will produce about 90 kwh.

FOSSIL FUEL PRICES TO UTILITIES

Fuel	National Average Price (cents per million Btu) September 1973	September 1974	Regional Price Variation September 1974 (cents per million Btu)	Average Percent Increase September 1973-September 1974
Coal	40.8	79.1	25.1 - 114.5	93.9
Oil	82.0	195.4	170.8 - 199.7	138.3
Gas	35.0	52.4	43.8 - 132.5	49.7

The following table describes the regional fuel mix and the weighted average cost to utilities for fossil fuels burned during June 1973 to June 1974 (in some instances percent figures do not equal 100 due to rounding off):

REGIONAL FUEL MIX AND WEIGHTED COST OF FOSSIL FUELS

Region	Percent of Coal	Oil	Gas	Weighted Cost per Million British Thermal Units in Cents
New England	12	87	1	128.1
Middle Atlantic	55	42	3	96.4
East North Central	93	4	3	55.3
West North Central	66	2	31	40.0
South Atlantic	63	30	7	80.2
East South Central	92	3	5	47.3
West South Central	3	7	90	40.3
Mountain	64	8	28	39.1
Pacific	7	53	40	91.5
U.S. Average	57	21	23	65.8

While the future of prices is always uncertain, various projections indicate the price of natural gas will most likely increase. The high demand for this fuel for nonindustrial uses indicates the proportion of gas-generated power will decline. Coal prices are expected to rise further as a result of the recent wage settlement in that industry, but the amount of increase is uncertain. Most uncertain is the future of petroleum prices. Among many factors that will impinge on oil prices, the Administration's recently proposed $3 import tax can be expected to cause a per-barrel increase of from 25 to 30 percent, and

deregulation of domestic "old oil" will also stimulate price increases.

Fossil fuel costs account for 20 to 40 percent of nonnuclear generation expenses. So long as prices for these fuels increase and so long as the vast majority of American electricity is generated by such fuels, the cost of power is expected to increase.

B. Capital and Facilities Costs

The electric utility industry is very capital intensive: in 1974 it took about $4.25 of investment to produce $1.00 in revenue. Typically, the industry gets 50 to 60 percent of its capital requirements in the open market in the form of debt capital, plus another 10 percent in the form of preferred stock. Given these facts, an increase in the interest rates and facilities' costs hits electric utilities particularly hard.

The cost of money has risen sharply in the last year. The yield on newly issued A-rated utility bonds rose from 7.54 percent in January 1973 to 11.05 percent in July 1974. By November 1974 the yield had fallen to an average of 9.90 percent. Some companies' bonds, however, still demanded as much as 12 percent. Average rates on all utility debt are, of course, below these levels, but the average always approaches the current cost. For the year periods ending September 1973 and 1974, total interest charges to 187 privately owned electric utilities rose 16.0 and 25.3 percent over the previous 12 months. On a kwh basis, interest charges during this time rose 10.0 and 22.7 percent, from 0.20 cents (or 2 mills) a kwh in 1972 to 0.22 (or 2.2 mills) in 1973 to 0.27 cents (or 2.7 mills) in 1974. Compared to the previous July, New England Region total interest charges were 40.3 percent higher in 1974 than 1973; in 3 other regions on which FPC provided data, comparable percentage increases ranged from 29.6 to 35.6.

Not only has the cost of money risen, but the investment required to produce a given kilowatt capacity increased dramatically. In the 1960s, while utility construction costs were rising about 2.5 percent annually, the nuclear facility costs were in the area of $125 per kilowatt. Plants being completed now are in the $400-a-kilowatt range, and nuclear facilities coming on line in the 1980s are projected at over $750 a kilowatt. The cost of fossil plants has also increased, though at a somewhat lesser rate. The average cost of coal-fired plants completed in 1968-1970 was $138 a kilowatt; in 1971-1973, it was $159 a kilowatt, an increase of over 15 percent. Electric power construction costs in the first 3 years of this decade generally increased annually over 10 percent and, according to FPC, greater rates of increase in cost per kilowatt of capacity are anticipated for the balance of the 1970s.

Should the present trend of falling interest rates continue, the utilities' financial burden will be eased somewhat. The industry's projected investment needs for the next 12 years are around $450 billion (compared to some $117 billion during the previous 12 years). This sum is a significant portion of projected national capital investment and indicates the utilities will face a real challenge in raising such large amounts.

C. Environmental Costs

Environmental regulations promulgated under the Clean Air Act Amendments of 1970 and under the Water Pollution Control Act Amendments of 1972 have thus far had a relatively small impact on consumers' electric bills. Costs to some utilities and their customers, however, have been considerably greater than the present national average. Additionally, the major cost impacts of the Acts will be felt in the decade which began in 1974.

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Data on current environmental expenditures are not plentiful, but to provide an example of the impact of current capital expenditures, the Investigative Staff obtained a summary of environmental investments made by 5 major utilities in Illinois. The expenditures were in excess of $290 million; however, the impact in customers' 1974 bills was small--0.033 cents a kwh, or about 25 cents a month for a 750-kwh consumer.

1. Clean Air Requirements

Regulations stemming from the Clean Air Act Amendments of 1970 define 2 standards for ambient air quality: the primary standards become effective in mid-1975, with possible 2-year extensions, which are designed to protect public health with an adequate margin of safety, and stricter secondary standards to protect the public welfare becoming effective within a reasonable time. The primary standards include limitations on particulate matter, nitrogen oxides, and sulphur dioxide, which are especially applicable to fossil-fired power plants.

Particulate emissions are usually controlled by electrostatic precipitators which impose an energy penalty of about 0.1 percent of a power plant's generation. Oxides of nitrogen may be limited by controlling combustion temperatures and other operating procedures, but, according to EPA, there are no good estimates of the energy penalties, if any, resulting from such actions.

Of more significance to utilities are the sulphur dioxide standards. Emissions of sulphur may be controlled by using fuel with naturally low sulphur content, by removing excess sulphur from the fuel before it is burned, or by removing the sulphur from the gases which result from combustion. Natural gas is extremely low in sulphur content but is scarce. Some quantities of coal and oil are available which are naturally low in sulphur and both may be

desulphurized. Though coal desulphurization is now uneconomical, desulphurization of oil is common.

If low sulphur fuels are not available, stack gas desulphurization (scrubbing) may be used to achieve the sulphur dioxide standards. While there is considerable controversy over whether scrubber technology is commercially feasible right now, given the large amount of ongoing research, few doubt that agreement on scrubber availability will soon be forthcoming. The loss of energy associated with stack gas desulphurization is believed to be about 5 percent; EPA has reported that in late 1974 the process was in use at only 19 different plants.

As the small number of installed scrubbers indicates, so far most utilities have opted for a clean-fuel strategy to meet air quality standards. Such an approach has meant an increasing reliance on oil products--products which were cheap and easily available before the Arab oil embargo and the consequent manifold price increase. While some utilities shifted to oil (when it was cheap) for other than purely environmental reasons, it stands to reason that utilities today would not be burning higher priced, low sulphur fuels--oil or coal--were they not required to do so. There is, therefore, a financial penalty associated with generating electricity from such fuels.

In September 1974, utilities purchased oil ranging from less than 0.3 percent to 3.0 percent sulphur content. The average price for the highest sulphur oil was $10.29 a barrel; for the lowest, $13.23 a barrel. Calculations based on the assumption that prices higher than the lowest constitute an environmentally imposed penalty and on a conversion factor of 500 to 550 kwh per barrel yield the following data:

LOW SULPHUR OIL PENALTIES, SEPTEMBER 1974

	Sulphur Content (Percent)				
	0.3 or less	0.31-0.50	0.51-1.00	1.01-2.00	Above 2.01
Barrels (000's)	7,647.1	9,928.1	9,980.1	4,444.1	7,967.1
Average Price/Barrel	$13.23	$12.89	$11.83	$10.79	$10.29
Cost Penalty/Barrel	$2.94	$2.60	$1.54	$0.50	-
Cost Penalty/Kwh	.53-.59¢	.47-.52¢	.28-.31¢	.09-.10¢	-
Total Penalty (000's)	$22,482.5	$25,813.1	$15,369.4	$2,222.1	-

Thus, though customers who took oil-generated electricity were generally charged less than half a cent a kwh for low sulphur oil costs, the total penalty associated with the use of such fuel was around $66 million in September 1974. On a national basis the penalty was equivalent to about 2.4 percent of utility operating expenses for the month.

According to several experts, the cost penalty for buying low sulphur coal ranges from $3 to $9 a ton, depending on the fuel's source, destination, and sulphur content. In September 1974, utilities received about 24.4 million tons of coal with less than 3.0 percent sulphur. Imposing a $3- to $9-a-ton penalty indicates costs were increased from $73.2 to $219.6 million and the penalty cost per kwh was about 0.15 to 0.45 cents. The possible range above represents 2.6 to 7.9 percent of the utilities' operating expenses.

The figures above are not intended to be exact. They serve to indicate the order of magnitude of national costs associated with a clean fuel policy. Actual costs for specific utilities vary considerably from the averages.

Given the scarcity of natural gas and the uncertainties and high costs associated with environmentally acceptable oil and coal, in the future more utilities are expected to move to plant modifications, as opposed to clean fuel, to meet sulphur dioxide standards. There is, however, considerable

uncertainty about what the ratio of fuel-to-capital solutions will be, as well as a lack of information on future costs of stack gas desulphurization.

Estimates prepared for the Investigative Staff by a private economic consulting firm, with the approval of a law firm representing an association of investor-owned electric utilities, indicate that compliance with the Clean Air Act requirements will increase consumer costs in 1985 by 3.1 to 8.4 percent. This would be equivalent to a monthly increase to the average residential customer (in 1974 dollars) of from $0.55 to $1.50.

2. Clean Water Requirements

The other major piece of legislation affecting electric utilities' operations is the Water Pollution Control Act Amendments of 1972. Recently promulgated regulations impose standards for chemical and thermal discharges from generating and other facilities. The most significant of the standards requires no heat discharge from power plants coming on-line after 1974 and from plants larger than 500 megawatts on-line after 1970.

An estimate provided to the Investigative Staff by the aforementioned organization of consulting economists indicated that by 1983, when all such standards will be fully operational, implementation of the chemical guidelines would impose additional costs of about $2.3 billion, and to meet the thermal guidelines, additional costs in the range of $8.3 to $10.8 billion. In other terms, the costs would appear to raise annual consumer costs by 2.7 to 3.4 percent and increase the average monthly residential bill by 48 to 61 cents.

3. Total Costs Associated with Clean Air and Water Regulations

Totals of the estimates provided by the private consultant firm indicate environmentally imposed costs will increase electric bills from 5.8 percent to 11.8 percent, an increment which translated into monthly residential

billings of $1.04 to $2.11. This estimate is somewhat higher than official Federal agency (FEA and EPA) forecasts. Federal predictions indicate air- and water-related environmental regulations will raise electric bills about 7.0 percent, or $1.25 a month, for the average residential customer by 1983.

In summary, costs to utilities, costs which are ultimately paid by consumers, have been at least as subject to inflation as other of our economy's costs. The rise in prices has been pervasive, and in the last 18 months it has been especially steep for the products electric utilities buy.

For lack of national industry data, it is beyond the scope of this report to attribute a specific amount of a bill's increase to a discrete factor. Data from one utility which has experienced somewhat less than average cost increases, however, provide an illustration of how general inflation and environmental regulations have raised costs.

The tabular data which follow are from a large midwest investor-owned utility whose generation in 1973 was primarily from coal (59 percent). The firm also has a significant nuclear capacity (30 percent), and oil and gas generation account for the remaining 7 and 4 percent of its total.

In 1971, the firm's average price was 2.03 cents a kwh; for the 9 months ending September 30, 1974, the average price was 2.56 cents a kwh, an increase of about 26 percent.

The following figures are only one example. Other utilities' experiences have been different, and the percentages which follow are not meant to be indicative of a national trend.

FACTORS INCREASING ELECTRICITY COST SINCE 1971, PERCENTAGES

Category	Environmental Requirements	Construction	Cost of Money	Other	Common Stock Return	Net
Fuel/Purchased Power						
Differential for Low Sulphur Fuel, Operation of Environmental Control Facilities	8.90					8.90
Peak Unit Operation				10.20		10.20
Generation and Purchased Power				14.73		14.73
Total	8.90			24.93		33.83
Other Operating Costs						
Labor and Pensions				11.74		11.74
Other				19.06		19.06
Total				30.80		30.80
Taxes						
Income				3.95		3.95
Other Than Income				14.73		14.73
Capital Charges	1.50	8.51	3.80	5.29	(2.41)	16.69
TOTAL	10.40	8.51	3.80	79.70	(2.41)	100.00

D. Other Factors Increasing Electricity Costs

In addition to the inflationary impact of the obvious factors just discussed, there are other, albeit less patent, circumstances which have contributed to the rising price of electricity. Utility spokesmen, who usually see price increases as resulting from events beyond their control, do not mention the industry's internal technical problems and inefficiencies as contributory to rate hikes. These problems, however, appear to be serious concerns of regulatory agencies, consumer groups, and many experts in the electric utility and energy fields. Since such items do not appear in the accounting procedures of the industry, they are difficult to quantify, and the degree of impact is debatable. But the direction of the impact is not debatable; it is to increase costs and prices.

1. Demand Reduction

In the long run it is possible that conservation of power will lower the cost of electricity, or at least slow the rate of cost increases; but since the Arab oil embargo, consumer conservation efforts have not led to appreciably reduced bills. Why is this so?

The majority of a utility's costs are fixed. A 10-percent demand reduction therefore reduces a utility's short-run costs by considerably less than 10 percent. With all other factors held constant, it is clear that short-run conservation will cause bills to rise if a utility is to maintain its earnings position. As real examples of this, several utilities have requested rate increases to compensate for losses due to reduced demand: Consolidated Edison--$108 million; Long Island Lighting--$19 million; New England Power Company--$2.5 million claimed for only one month. By early Spring 1974 at least 12 other similar requests had been filed throughout the United States. Whatever has been

the effect of factors besides conservation--a declining economy, more favorable weather, or higher bills--the total amount of electric energy recently taken compared to previous 12-month periods has been considerably below what the utilities had planned and had capacity for.

To compound this exacerbating situation, the reduction in demand has not been uniform. Utilities establish generating facilities to meet requirements on, say, the hottest day--the peak--plus reserve facilities to compensate for routine maintenance and breakdowns. Such facilities built to meet peak demand are computed in a firm's rate base but remain idle much of the time. While general conservation has occurred, demand in the peak has slackened little, if at all. Should such a condition continue, a utility would be reluctant to reduce or slow growth of its total plant and the long-range savings possible from conservation will be severely restricted.

2. Equipment Unreliability

Officials at FPC have voiced concern over the amount of time generating equipment is not available for service, that is, concern over equipment unreliability. Equipment reliability is essentially composed of 2 elements--the amount of time the equipment is available for service (availability) and the amount of real output, as compared to its expected output, the machine produces when it is in service (capacity). Under perfect conditions, plants would produce 100 percent of their design capacity all the time.

Obviously, perfection is impossible. Equipment must be shut down for routine maintenance and unexpected outages; it needs to go through shakedown periods--reality moves away from perfection.

For example, a report to the FEA observes that nuclear light water reactors have been built with design expectations of capacity and availability

factors close to 80 percent. For a variety of safety and technical considerations, however, capacity has been considerably below 80 percent, as has availability.

In addition to observing this general failure of nuclear generators to meet expectations, the report noted that plants were not achieving design ratings even after an expected break-in period of 3 to 4 years. The data showed that for the first 3 years or so, as the "bugs" were worked out of nuclear facilities, capacity and availability factors rose (but not to 80 percent), but that this level was not maintained. In fact, after the bugs were out, other problems associated with age began to lower capacity and availability factors. The report showed nuclear average capacity factors of 57 percent (1973) and 50 percent (first half of 1974) and average availability factors of 69 and 59 percent for the respective time periods.

One might expect that since generation from nonnuclear facilities has been going on for decades, this part of the industry would be in good shape. This, however, is not the case. An FPC official stated that the average availability of fossil fuel-fired generators had declined considerably. For large (600 megawatts or greater) units the forced outage rates are more than twice as great as for smaller units.

The causes of this lack of reliability are manifold. Design faults, construction mistakes, poor quality fuel, and others are named by FPC officials when one asks why.

Whatever the cause of equipment unreliability, its result is fairly clear. Shutdown generators cost money. One consultant estimated that customers' bills may have been increased 5 to 10 percent as a result of poor equipment performance.

Besides meaning that a utility gets less than it pays for, unreliability means the utility must pay for more. As a general rule, groups of interconnected utilities--power pools--attempt to establish reserve generating capacity so that demand will not exceed capacity for more than 1 day in 10 years. Unreliability means greater reserve capacity requirements, higher utility investments, and higher bills.

It is interesting that an FPC official advised that the 1-day-in-10-years reliability criterion was arbitrarily established without the aid of cost-benefit analysis or other cost-conscious methods.

3. Industry Inefficiency

While the electric utility industry is the largest in the nation, in terms of capacity use it is also considered one of the most inefficient. The industry's annual load factor (the average load supplied during a designated period compared to the peak load occurring in the same period) was 65.5 percent in 1960. Since that time it has declined to 62.0 percent in 1973--a measure of increasing inefficiency. Reduced energy consumption in 1974, coupled with maintenance of peak-period demands, indicates that the national load factor probably declined even more last year.

As with equipment unreliability, inefficiency in this context means the industry is paying for capacity it uses only a portion of the time. The relationship is not one-to-one, but should the industry manage to increase its load factor, to spread the same amount of demand more evenly over a day or year, it would need less capital facilities. Additionally, operating costs might be reduced since units used to meet peak demand are usually the least fuel-efficient.

V. REASONABLENESS OF CURRENT ELECTRICITY COSTS

The reasonableness of recent increases in electricity prices is often dependent on one's point of view or on the factors considered when defining reasonableness. To regulatory commissions, charged with establishing rates fair to both consumers and utilities, rates are generally reasonable. Admission that rates were anything else would be acknowledgement of failure to perform statutorily mandated tasks. If representatives of the utility industry think rates are unreasonable, they believe they are too low. Those with this viewpoint cite the industry's financial plight to support their position. Ratepayers, that is, consumers, of course see rates as unreasonably high.

Much of the adverse public reaction to recent rate and fuel pass-through increases is probably the result of experience with relatively low electricity prices. Rates which had been rising almost imperceptibly, or which had actually declined in the 1960s, skyrocketed during 1974. The result was a conclusion, sometimes emotional, that rates were unreasonable.

Using a test of reasonableness which relies on experience unquestionably has caused consumers to become angry. Officials in Florida told the Investigative Staff of increased consumer resistance to higher electric rates being manifested in the growing incidence of delinquent bills. More amazingly, some responsible Floridians favor "building a fence" around the state to discourage the continued influx of citizens and the attendant new and costly demands on utilities. One method of building such a fence, it is being suggested, would be to impose a capital facilities fee of from $300 to $500 on each new electricity meter installed.

In Massachusetts, some state officials expressed fears that unless rate increases are slowed, there will be burgeoning demands for public ownership of

electric utilities. A recent newspaper report indicated a vocal group of Maryland homeowners had voted to withhold part of their electric bill payments to protest high prices.

To industry representatives such activity is unfortunate and, they claim, at least partly stems from public misunderstanding of the industry's condition. There is little doubt that today many electric companies find themselves in poor financial condition. Profitability has declined. The ratio of market value to book value of utilities has fallen, and many utility stocks are selling below book value. There are numerous cases of failure to earn permitted rates of return. Investors are leery. And this financial malaise comes when projected utility investment requirements are considerably larger than they were in the last decade.

From 1972 to 1973, investor-owned utility operating revenues and expenses both rose at a rate of 8.9 percent. Comparison of 12-month periods ending in September 1973 and 1974, however, shows that operating expenses rose faster than operating revenues--25.7 percent versus 22.8 percent.

Utilities which rely on such factors to determine rate reasonableness can conclude prices are not high enough. To the industry, these statistics indicate the regulatory process should be speeded up and perhaps liberalized.

Regulatory commissions seem to recognize they are dealing with a troubled industry, and there are indications they are beginning to adopt practices to help ameliorate the distress. But, as noted later in this report, the proposed new practices will have the general effect of raising rates.

What can be said about the oversight of the regulatory commissions? On the positive side, one must note that under their guidance the integrity of the utilities has generally been maintained and consumers have been supplied with

abundant power. Until recently, few questioned the rates they approved.

On the other hand, there are state regulatory commissions whose professional staffs have been demoralized by political interference with their recommendations, commissions which lack adequate staff to present a full case in rate hearings, and staffs which lack expertise and depth. It seems that most regulatory commissions will soon require significant staff additions to process effectively the recent deluge of rate filings. Additionally, staffs of some of the commissions visited by the Investigative Staff said there were isolated instances where they believed the commissioners (the appointed or elected decisionmakers who may serve full or part time) had erred in giving utilities higher than justified rates. In a more sweeping indictment of present commission outlooks and practices, the FPC chairman has stated, "Past patterns of rate regulation cannot serve present needs. Regulatory innovation and leadership are necessary to meet the economic and financial challenges facing the electric industry."

In general, however, it seems that state regulatory commissions have followed the practice of allowing higher rates to reflect higher costs to the utilities. One consumer representetive in Massachusetts explained that he, as a consumer, considers present electricity prices in his community as "outrageous." However, as a pragmatist and, consequently, looking at such rates purely from a cost basis, the way regulatory commissions look at ratemaking and define reasonableness, it would be difficult even for him to argue with recent price trends. In that light, he described his electric bills as generally reasonable.

But there is no doubt that consumers, even those who recognize the electric power industry may not be getting rich from imposition of new rates, are asking

questions and demanding relief. Why should electric utilities not share with everyone else the distress of reduced income brought on by higher prices? Are all the price increases passed on to consumers really beyond the industry's control? What are electric utilities doing to keep prices down, or to keep them from rising so fast?

To the extent that utility income is not keeping pace with expenses, the industry is sharing the financial burden of higher costs and prices. This fact, however, is generally a result of regulatory exigencies, not policy. After all, by law, regulatory commissions are required to permit privately owned utilities an opportunity to recover costs and earn a fair return. Low returns on rate bases are thus "accidental" in that no one foresaw the intense effects of inflation and other disrupting events.

It is the opinion of several consumer-oriented experts in the utility field that most cost increases which the industry is experiencing are beyond the control of the individual utilities. A power company cannot wait until fuel prices fall before buying coal or oil. One energy expert suggested that the only realistic way to achieve lower fuel costs was to impose national price controls, a move which seems unlikely at this time. In New York, the regulatory commission is taking steps to assure all utility contracts are as competitive as possible, but officials do not expect this tactic to have much impact on prices. Industry spokesmen do not see removing the "fat" as an effective means of controlling, or lowering, price because they do not feel there is much excess to remove.

As evidence of the industry's claimed concern for its customers' interests, utility officials cite legal actions which have been initiated against suppliers for contract noncompliance as an effort to lower fuel prices and automatic fuel pass-throughs. One utility company which sells power

acquired mostly from other utilities noted that its representatives participate in rate proceedings and assume adversary roles at such hearings, as might any other customer. Large companies, too, are often set up so that they can purchase power from a neighboring utility when, in any given hour, that neighbor is producing electricity more cheaply than the buyer.

Utilities have also engaged in campaigns urging consumers to conserve electricity. At the same time that such campaigns are urging the conservation of electric energy as vital to the national interest, they also observe, "But remember, even though you do cut back your use of electricity, your electric service bill may not be lower."

With their desire to expand and their recognition that reduced use of power can eat up profits unless "conservation" rate relief is granted, it would seem that most utilities lack real incentive to lower consumption. Representatives of a large midwestern investor-owned utility admitted that, even though the electric power industry is no longer one of declining costs, their company must continue to have growth in order to "catch up" with the plant construction already committed. For them, a dramatic reduction in demand growth could only have a "horrible" financial impact on the finances of the company.

Another utility spokesman summed up the position of his company in a statement which is probably representative of industry thinking:

> "It is clear that the days of cheap, abundant energy are over. In the years ahead, this nation will move increasingly toward an electric society as coal and nuclear power assume larger shares of the country's energy base. It is critical, therefore, that utility rates meet expenses and generate adequate returns on investment to attract capital which provides the means for expansion and continuation of reliable service."

He noted the inevitability of "further and continuing substantial increases in cost of producing and distributing electricity" resulting from inflation and other causes "seemingly beyond man's control." Additionally, he said that consumers should not be overburdened with environmental controls where the costs surpassed the benefits.

Put another way, this industry representative expects rapid growth in electricity demand at substantially higher prices, and he suggests strict environmental accounting to help keep the price of power down.

During the next 8 years, FEA envisions electricity prices (in 1974 dollars) rising about 42 percent. Of this increase 7 percent would result from environmental requirements and the remaining 35 percent from other factors. From the foregoing statement, it would appear that one representative privately owned utility has decided the projected 35 percent increase falls in that province "beyond man's control" and has opted to reduce projected costs associated with environmental regulations. From a consumer viewpoint, one must conclude that whatever the electric power industry has done to help control prices has not been effective. Nor is there any evidence that consumers will find future rates more to their liking.

When assessing whether present rates charged by utilities are reasonable, it is important to remember the rapidity with which the cost increases have come to the industry. Inflation that seemed high in 1973 grew at an even faster pace in 1974. Fuel prices doubled and tripled virtually overnight, and other costs rose too. It would have been next to impossible for the industry and its regulators to have responded quickly in any other way but to urge and effect timely compensation for increased costs. Other responses would have necessitated drastic policy changes.

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It may well be, given present utility structure, economies, and policies, that many of the industry's costs are largely uncontrollable. Recent experience, as well as present cost projections, however, suggests some new strategies may be necessary. It is possible that economic conditions and internal utility efficiencies have changed enough to require modification of traditional approaches to generating and selling electricity.

While regulatory commissions are considering a variety of devices to ease the crunch on utilities, so far the industry itself appears to have responded to its troubles in a most traditional and predictable way--raise rates more, faster. Further, aside from traditional economy and efficiency drives, the industry does not seem to be seriously considering alternative methods of doing business.

The following comprise a partial list of promising approaches to the problems of rapidly escalating rates and utility financing which have been put forward as deserving more attention from the industry:

(a) Efficiencies possible from the institution of peak load pricing, at least for some portion of the industry's customers, as a beginning point.

(b) Increased interconnection of generating and transmission systems so that utilities may share or swap power when one firm is experiencing excess generating capacity.

(c) Expanded research and development activity. The electric power industry historically has invested a relatively small percent of its income in such activity.

(d) Increased emphasis on quality control of equipment manufacturing and construction practices.

(e) Cessation of load growth promotion and emphasis on conservation in the industry and among its customers.

(f) Sophisticated load growth projections to assure that capacity is expanded in a timely manner.

(g) Early disclosure of siting plans to minimize delays and expense associated with citizen interventions.

Utility spokesmen may be correct in saying more money will solve most of their financial problems, at least for the short run. But unless utilities seriously consider innovation now, consumers may be able to amount an effective future campaign based on "unreasonable rates." A citizen in 1980, observing a long history of price increases, could reasonably conclude the utilities had had ample time to begin controlling those seemingly uncontrollable costs or to begin producing power emphasizing other, more controllable factors. It will be unfortunate if the industry does not engage in serious evaluations of activities which could increase efficiencies and which would look forward instead of backward.

VI. ELECTRICITY AND ENVIRONMENTAL REGULATIONS

Ever since man discovered fire, his production of energy has been polluting the earth.

In addition to the Federal agencies which regulate the electric utility industry from an energy or financial point of view, the efforts which have focused in recent years on cleaning up the environment have resulted in a host of Federal and state agencies promulgating environmental regulations which impinge on the production of electricity.

The National Environmental Policy Act of 1969 declared a governmental mandate and responsibility for environmental quality, established the Council on Environmental Quality, and provided for administrative procedures which required all Federal agencies to prepare an "environmental impact statement" on proposed Federal actions which significantly affect the "quality of the human environment."

In addition to the broad requirements of the National Environmental Policy Act of 1969, the Federal agencies which have issued specific regulations which significantly impact on the source and supply of electricity include EPA with its clean air and water regulations, FPC and its administrative and rate regulation of the electric utility industry, and the Nuclear Regulatory Commission with its nuclear regulatory and licensing authority. (The roles of the FEA, Department of the Interior, and Department of Commerce will be addressed in a subsequent report.)

The energy crisis in the United States, aggravated by the Arab oil embargo in late 1973, has modified and intensified the debate on energy and environmental issues. Prior to arrival of the crisis, the energy-environment debate largely involved the issues of energy production's impact on the environment

and the possible necessity of societal changes which would stem from environmental regulation. Most recently, this dialogue has become more concerned with the environmental regulations' impact on the production and availability of energy and the question of whether environmental legislation is overly restrictive.

One method of evaluating environmental, and other, regulations which the electric utility industry favors is measuring costs and benefits. While such an approach may be theoretically appealing, in actuality its application has so far proven to be difficult and subject to controversy. For example, while an FPC official called costs associated with environmental controls "great," he was unable to produce any national data on actual environmental expenditures which resulted specifically from Federal regulations. FPC is in the process of amending its system of accounts so that utilities' environmental outlays may be measured, but this change is not yet effective.

Individual utilities have the ability to measure and project their own costs which are a product of environmental regulations, but estimation of benefits is much more difficult, even when a utility attempts this exercise. For example, how does one definitively quantify benefits which range from protection of human health to less frequent need for house painting? One representative of an industry research group pointed out that no good study of air pollution control costs and benefits exists. EPA officials claimed that no good, comprehensive cost-benefit studies of either air or water pollution control have been conducted. These officials say that the benefits accruing from their agency's regulations are virtually impossible to quantify. EPA recently rejected, on methodological grounds, an industry analysis of costs and benefits associated with clean water regulations.

Should the experts be able to overcome the difficulties inherent in making useful cost-benefit analyses, there remains the question of whether policies should be made on such a basis. The evolutionary development of U.S. energy policy has been one in which individual policy decisions were made in response to the needs of the time and rarely were concerned exclusively or even significantly with energy supply or demand. The absence of a clear, comprehensive national energy policy makes evaluation of environmental regulations in terms of energy needs less relevant than one would like.

The following discussion of Federal agency environmental regulations and their impacts on the source and supply of electricity is, then, not intended specifically to suggest amendments in the regulations but more to point out where various agencies seem to be heading and the industry's response to some of the constraints imposed by Federal regulatory activity.

A. Environmental Protection Agency

EPA regulations have had important consequences for the sources and supply of electricity.

Under the Clean Air Act Amendments of 1970, states established strategies--state implementation plans--to clean up their air. EPA was designed as the agency to approve state implementation plans, and the Act has been administered so that clean air, with possible variances, is to be obtained at the primary standard level by mid-1975.

The air quality regulations have been an important factor in causing the switch in fuels used to generate electricity. In the 8 years from 1965 to 1972, 398 coal-fired boilers, with a total capacity of 28,785 megawatts, were switched to oil. Even today, when Federal policy is to encourage coal-fired generation, the Investigative Staff learned of one instance where the Florida state pollution control agency, as of January 1975, was requiring that a power plant convert from coal to oil generation.

It seems likely that some state implementation plans were produced too quickly or with too little evaluation of the impact their requirements would have on the supply of electricity. Several of the plans included stringent limitations on emissions which have produced what is known as the clean fuels deficit--that is, an insufficient supply of low sulphur coal. EPA officials admit that their agency had approved state implementation plans with little awareness of the margin of "overkill" that was being introduced. For example, regulators and utility representatives in Florida pointed out one area of the state where emission standards being enforced are below the technically detectable levels and several times more exacting than national standards. Utility spokesmen in other areas noted that they are required to burn low sulphur fuel all the time when ambient air standards could be maintained by using such fuel only a few days in a year. Generally, the electric power industry maintains that making the air cleaner than is required by Federal standards, which are designed to protect human health and the environment with an adequate margin of safety, is wasteful.

Efforts to revise the extremely limiting emission standards set by states are underway. The Energy Supply and Environmental Coordination Act of 1974 requires the EPA administrator to review state implementation plans to determine the feasibility of revising these plans. Under its clean fuels policy, EPA had, by late 1974, approved or expected to approve within about 6 months revisions of state implementation plans to allow the burning of an additional 71 million tons of coal annually. FEA officials have suggested that quicker revisions could be effected by congressional action.

Additionally, EPA has proposed to ease pressure on coal-burning utilities by allowing, until 1985, the use of cheaper supplementary (nonscrubber) control systems to maintain ambient air standards where this strategy is feasible and

enforceable. An EPA analysis showed that between 18 and 70 plants, mostly rural, would meet these criteria.

In another move to assure that coal may be burned, EPA has also pursued a policy of administratively extending compliance deadlines. It does not appear that EPA is going to close power plants when a utility, in good faith, has not achieved a standard.

While cleaning up the air imposes a penalty on utilities and their customers in the form of higher fuel costs, it also produces an energy penalty when utilities select nonfuel means of complying with clean air requirements. EPA estimates that clean air requirements for utilities will impose an energy penalty equivalent to 145,000 barrels of oil a day in 1980. This total includes energy which will be expended for particulate control, stack gas scrubbing, and desulphurization of fuel oil. Both EPA and FEA officials consider this penalty as small and clearly affordable.

The clean water standards resulting from implementation of the Water Pollution Control Act Amendments of 1972 are scheduled to become effective in stages in 1977 and 1983. An economic consultant representing several privately owned utility firms has stated that the investment required to meet the 1977 clean water standards will in large measure meet the 1983 requirements as well.

From a cost point of view, the most significant results of this Act are the guidelines calling for no thermal discharge from generating units larger than 500 megawatts coming on-line after January 1, 1970, and, essentially, from all generating units coming on-line after January 1, 1974. An industry group has estimated that compliance with the Act will require capital investment of $9.1 billion; EPA's estimate in this regard is $4.1 billion. Although the capital costs will thus be significant and may provide grounds for a re-examination of the regulations promulgated under this Act, the energy penalty

associated with compliance is not expected to be large. EPA, for example, estimates that compliance with the clean water regulations will use energy equivalent to 50,000 barrels of oil a day in 1980, an amount which neither EPA nor FEA considers excessive.

From an industry point of view, EPA's clean water regulations are overly stringent. Perhaps most troublesome to the utilities is the requirement that plants larger than 500 megawatts on-line after January 1, 1970, must comply with the thermal discharge standards. For many such plants compliance will require backfitting, a process estimated to cost 3 to 4 times as much as installing cooling towers at the time of original construction. This matter is being contested in the courts.

A second major industry contention is that EPA's rules and guidelines for permitting exemptions to the thermal discharge requirements are unclear. One section of the Act states that exemptions may be granted when less stringent limitations "will assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made." The industry claims that EPA has not clearly defined "indigenous" so that estimates of possible exemptions are not meaningful. (This is one reason for the disparity between the EPA and industry capital investment estimates of complying with the Act: the industry estimate does not include possible exemptions while EPA's estimate does.)

Although it is unclear how these legal and administrative disputes will be resolved, it is interesting to note that one energy expert with the reputation for being consumer-oriented told the Investigative Staff that water pollution is not as great a problem as fouling the air in that dirty water does not usually harm human beings physically. Writing about the nature of our energy problems, he said:

"The problem of thermal pollution should be kept in perspective. Many power plants are spending more money on cooling towers than clean air equipment. Investment in cooling towers should be no larger than what is actually needed to preserve water quality. Further research on the amount of heat waterways can tolerate and on how to dissipate heat more efficiently--or better still, beneficially--could pay big dividends both to the power industry and to the public."

B. Federal Power Commission

Although the FPC does not issue regulations that may be called strictly environmental, its regulation of various aspects of the natural gas and electric utility industries does affect the source and supply of electricity.

The following are examples of how FPC regulation has impacted the electric power industry:

In its regulation of the scarce supply of interstate natural gas, FPC has issued curtailment priorities. Use of natural gas as a boiler fuel receives very low priority. Industry representatives have noted that, while the precise impact of this policy has not been quantified, it probably has contributed to the decline in natural gas use by utilities. Shifts away from gas boilers have meant increased use of oil and coal, both of which are more expensive than natural gas.

More directly, several FPC rules and methods of regulation contribute to increased costs for electricity, at least in the short run. These policies, discussed elsewhere in this report, include consideration of future test years for ratemaking purposes, the automatic fuel adjustment clause, and shortened periods of suspension of proposed rate changes. Such procedures are designed to ease the financial plight of the electric utilities in a time of rapid inflation. They all tend to allow higher costs to be passed more immediately to the consumer.

C. Nuclear Regulatory Commission

Nuclear power plants are subject to local, state, and Federal regulations. Local and state regulations are mainly concerned with zoning, waste management, and thermal effects; Federal regulation concerns matters related to the National Environmental Policy Act of 1969, effluents, and nuclear safety.

Federal regulation and licensing of the growing atomic energy industry are vested in the Nuclear Regulatory Commission (NRC), a new agency whose activities are those which were transferred, without alteration of regulatory structure, from the former U.S. Atomic Energy Commission by the Energy Reorganization Act of 1974.

Applicants for nuclear power plant licenses must obtain both a construction permit and an operating license from NRC. The construction permit application must include data on the reactor type, safety characteristics, site features, and environmental impact. The application is subject to review by some 4 divisions within NRC, and, after the reviews are completed, a mandatory public hearing is held. Although a public hearing is not required for an operating license unless the grant is contested, the second license is generally subject to the same stages of review as the construction permit.

Licensing and construction of a nuclear generating facility take 8 to 10 years, and plant completions have been plagued by delays. One report has identified delays of 7 to 70 months experienced by 27 nuclear units scheduled for service during the Summer of 1974. According to the FPC, the delays were the result of labor problems, technical and engineering problems, regulatory problems at the local, state, and Federal levels, and legal problems. Delays have generally resulted in escalated costs.

Since 1971, the time required for licensing nuclear power plants has been reduced from about 3 years to around 18 months. According to a draft FEA study, further reduction of licensing time will probably require legislation.

For example, the National Environmental Policy Act of 1969 requires NRC to review all environmental aspects of a plant, regardless of whether other agencies have examined them. Industry officials view such redundant reviews as particularly wasteful and expensive.

In 1974, the former Atomic Energy Commission suggested new legislation be considered with 4 basic objectives: to obtain earlier decisions on facility siting, lessen the possibilities that operating licenses may become delaying factors, encourage taking advantage of generic designs, and offer several approaches to licensing to permit more flexibility than the present process allows.

Industry representatives have also suggested several specific legislative changes to expedite this licensing process: elimination of mandatory hearings for a construction permit unless such hearings are requested; limiting the scope of operating license hearings to matters that were not at issue in construction permit hearings or to newly discovered evidence; provision of authority for NRC to issue interim approvals of operating licenses or amendments to existing permits prior to completion of pertinent hearings where such changes could be justified by the need for power or other aspects of the public interest; certification of sites in advance of a construction permit application to produce, in effect, a site bank; statutory changes to facilitate the NRC policy of plant design standardization to end redundant case-by-case consideration of design and to remove generic issues from individual plant licensing hearings.

It is the opinion of many industry spokesmen that their suggestions would go far toward reducing the costs and uncertainties now associated with nuclear power. For example, one economic consultant has estimated that a 900-megawatt

nuclear unit operating at a 60-percent capacity factor saves the equivalent of 8 million barrels of oil annually. At current fuel prices such a nuclear unit is estimated to produce a net savings of around $60 million a year. Unnecessary delays thus postpone such savings, as well as increase the capital costs of a facility as a result of inflation.

It should be noted, however, that this estimate of savings may not be definitive. Although a responsible FPC official was unable to provide quantitative support for his statement, he said that, considering all factors (including consideration of the investment penalty for the higher capital costs of nuclear plants and the higher license fees and insurance), electricity generated by nuclear plants costs about the same as that from nonnuclear facilities. Nuclear fuel, however, is abundant right now while other fuels are clearly either in short supply or very expensive.

D. National Environmental Policy Act of 1969

In addition to stating a governmental mandate for environmental quality and establishing the Council on Environmental Quality, the National Environmental Policy Act of 1969 requires environmental impact statements from all Federal agencies which propose actions that will significantly affect the environment. As a result, Federal agencies are required to examine the proposed action's environmental impact, unavoidable adverse environmental impacts, alternatives, the relationship between short-term use of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Officials at FPC told the Investigative Staff that requirements under this Act had significantly delayed construction of needed energy facilities; they added, however, that quantification of delays associated specifically with the Act was not available.

One attempt at such quantification by a Congressional Research Service analyst concluded that environmental delays occasioned by this Act, while costly, have not been of the magnitude that many claim. For example, environmental litigation was responsible for 6 percent of the delays in generating capacity installed between 1966 and 1970; of 242 plants scheduled for completion between 1969 and 1974, some 11 percent were delayed for environmental reasons.

While environmentally-caused delays may not be as great as FPC or industry spokesmen estimate, such delays are onerous and expensive. Not only this, they tend to encourage the construction of fossil-fueled plants, as opposed to nuclear facilities, because regulation is less stringent, environmental impact more "traditional," and construction times significantly less.

While utility representatives state that specific standards and regulatory practices have resulted in higher costs and project delays, they cite a more pervasive ill effect on the regulatory umbrella under which they must operate: numerous regulations, overlaps, redundancies, and sometimes conflicting approaches among Federal agencies and between Federal and non-Federal agencies relative to environmental matters produce a general atmosphere of uncertainty which makes planning a most trying process.

The capital investments of the industry are immense and long-term. To an industry official, it is exasperating for the Federal Government to allow a switch from oil to coal for 5 years if he has little idea of what he will be told to do when the 5 years is over. It is confusing to have FEA urge conversion to coal from other fuels while state agencies demand use of low-sulphur oil.

Many utility spokesmen believe such uncertainties could be reduced by the creation of an effective, long-term, comprehensive national energy policy.

Several utility representatives expressed the belief that even a "bad" national energy policy would be an improvement over the cross-purposes which characterize the controls and absence of coherent policy they presently experience.

VII. OUTLOOK FOR FUTURE IS BLEAK

The last year or so has been a turbulent period for the electric power industry and those it serves. The rate of consumption increases has fallen and in some places there have been absolute declines in power production. The industry, faced with high general inflation, difficulties in raising capital, and failures to earn the permitted rates of return, has become financially strapped. Some construction projects have been canceled or deferred because of lack of money, and others have been delayed because of revised demand projections. At the end of the line, the consumer has received higher bills.

What is going to happen now? Although the most expert predictions have a tendency not to be fulfilled, there is unanimity among representatives of utilities, regulatory agencies, and consumer groups that the future is bleak. No one with whom the Investigative Staff spoke believed American consumer could look forward to a return to pre-1973 electric rate levels.

A. Suggestions for Change

While the prospects for all who make or use electricity are indeed discouraging, there are proposals, admittedly neither easy nor painless, which have been advanced to remedy the present unhappy circumstances. In September 1974, before a meeting of state regulatory commissioners and Federal officers, the chairman of the FPC summarized his ideas on possible public policy innovations that are available for improving the electric utility industry's financial plight.

One option mentioned was to include construction work in progress, in the same manner as completed plants in operation are now considered, in the rate base. This would allow utilities to earn returns on facilities not "used and useful" and, thereby, ease the utilities' case flow problem, but would

require regulatory policy change because the "used and useful" concept is ingrained in state regulatory practices. If implemented, this policy option would also have the immediate impact of increasing rates about 11 percent and tend to remove the financial incentive for rapid completion of capital facilities.

The chairman also recommended the use of future test years, rather than historical test periods, for establishing rate bases and reducing regulatory lag. (The Investigative Staff observed that this practice is already being used by FPC and is being increasingly followed at the state level.) The use of future test periods, especially in times of rapid inflation, makes it more likely a utility will earn the permitted rate of return. He also recommended wider application of fuel adjustment clauses to buffer the industry against further erosion of its earnings, and consideration by Congress of tax law revisions to accommodate such policy alternatives as increasing the utilities' investment tax credit from 4 to 7 percent, permitting stockholders of electric utility companies to choose either a tax-sheltered stock dividend or a taxable cash dividend, and more widespread use of tax-exempt bonds for pollution control facilities.

To utility executives, the FPC chairman suggested that a review of the traditional methods of pricing their services was long overdue.

> "Management should seriously consider the abandonment of declining block rate schedules unless this pattern can be thoroughly cost justified. Flattened rate schedules that reflect long run incremental costs seem eminently reasonable on economic grounds. Additionally, any latent discriminatory differentials in rates among classes of customers should be expunged. The two-fold difference between residential and large commercial customers' rates may not be cost justified."

From the foregoing, it appears that the prescriptions advanced lean markedly toward ameliorating utilities' and investors' fiscal aches and

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pains. But what hope was offered at that same time to the public, the consumer, to alleviate the alarm and anguish which have greeted the sharp and dramatic increases in electric bills, with additional increases imminent? Only that "industrial and other customers should be assisted to improve the utilization of energy at the point of consumption."

While the Investigative Staff has not made an independent analysis of these proposals, some general comments are in order.

The suggestions relevant to regulatory commissions would all have the impact of easing the financial strains on the industry, and, since it is the consumer who ultimately provides the revenues, implementing such innovations would also raise rates.

Electric utilities appear reluctant to alter rate structures. Rate flattening and peak load pricing, important considerations for the future, would increase costs for large users and for those who use power during the peak. As the FPC chairman indicated, these innovations would also have the effect, to some unknown extent, of slowing peak load growth and reducing investment requirements. Utility representatives, though admitting they had no real idea of precisely why consumption rates plummeted in 1974, said they thought that year might be a "one-shot" experience. Many hope and expect to return to the more historical 7 to 8 percent annual growth rate in 1975.

Electric utilities believe growth is in their interest. It, among other things, makes their stock more attractive and enables them to use up excess generating capacity. Economically rational growth (with all customers paying full costs for the increased use of a product) would seem fair. The FPC chairman at least implied all utility growth may not be as economically rational as one would like. Additionally, state regulatory officials have admitted that all rates may not be fully cost justified.

To the extent that electric bills are not fully based on costs, customers get incorrect economic signals. To the extent that rates are discriminatory, one group takes more power than it should. Except possibly for fulfillment of social goals, uneconomic growth is never desirable. It means that someone is getting a cheap lunch at another's expense.

In the case of the electric power industry, uneconomic growth seems particularly abhorrent. It strains the industry unnecessarily while depleting valuable national resources. Moreover, so long as the cost of electricity produced at new facilities is greater than a utility's average production cost, a condition the industry seems to have reached in the past few years, growth will increase everybody's electric bill. We have no more need for promotional growth. As some utility pricing experts have suggested, "... the cost of additional capacity will continue to dominate rate proceedings. It is the fundamental and persistent reason why the price of electricity can be expected to rise."

In addition to the suggestion for a reevaluation of historical pricing and rate design, the Investigative Staff believes one other approach to making the price of electricity more economically rational might be profitably pursued. This is in the area of load forecasting. The following example is nonscientific since information comes from only one state, New York. The New York Public Service Commission, however, does enjoy an excellent reputation among state regulatory officials, and, to the extent this reputation is true, the following represents a "best case" discussion.

Projecting load growth is complex. At best, it uses quantification which, according to the New York commission, relies on methods of limited reliability. Still, in late 1974, that commission found generally that the utilities' forecasting methods were "unsatisfactory."

After examining one utility's load growth projection, the Consumer Protection Board of the State of New York found that the company had made no attempt to identify the impact of price on demand and that load forecasts had been based extensively on recent high growth trends. The Consumer Protection Board concluded that the state regulatory commission should revise its overview of the company's construction projections and warned of the financial risk, to the company and its customers alike, inherent in the proliferation of excess capacity.

Especially in a time of consumer suspicion of utility activities and motives, it is imperative that utilities engage in rigorous growth projections. While the electric power industry has the obligation to assure a reliable and adequate power supply, it must discharge the obligation as prudently as possible.

Finally, it is the assigned role of regulatory bodies to balance consumer interests with those of investors to insure that the public interest is served. That being the case, is it sufficient to propose a host of innovations directly applicable to utilities and investors and, at the same time, indicate that the only direct support users can look forward to is further education from utilities' management "to improve the utilization of energy at the point of consumption"?

From the consumers' view, as even the FPC chairman has noted, "There appears to be no rhyme or reason to the sharp and dramatic increases in their electric bills." The dreary spectacle confronting consumers already includes the reality that automatic increases appear in their bills at the same time that they have decreased consumption. Utility regulators would answer that the interests of the consumers are those of the utilities. Such a response

offers little solace to angry ratepayers. They see regulatory agencies proposing changes to shore up the electric power industry and placate investors but no concomitant substantive recommendations that will translate into relief to their pocketbooks or belie the growing suspicion that the burdens on the industry are merely being transferred to the public at large.

B. Impact of Administration's Energy Proposals on Electricity Prices

In his State of the Union message on January 15, 1975, the President unveiled an energy program designed to begin restoring this country's surplus capacity in total energy, reduce domestic energy consumption while increasing production, and enable the United States to achieve energy independence by 1985.

A number of the proposals--including the request for legislation to make thermal efficiency standards mandatory in all new buildings in the United States, significant investments in all domestic energy sources, and increased expenditures for energy research and development--will not have significant impacts on electricity prices in the short run. The following specific proposals, however, appear to be those which would impact greatest and more immediately on consumers' electric bills.

(1) A tariff on all imported crude oil rising to $3 a barrel by April 1, 1975, that is, an average $2 a barrel for 3 months.

(2) A more permanent excise tax of $2 a barrel on all crude oil used in the United States and decontrol of old domestic oil (from wells placed in production prior to 1973) prices on April 1, 1975.

(3) An excise tax of 37 cents per thousand cubic feet on natural gas and deregulation of the price of new natural gas.

(4) Selective changes in state utility commission regulations.

(5) An electric utility investment tax credit of 12 percent for 3 years, specifically to speed construction of generating facilities which do not rely on natural gas or oil.

(6) Amendments to the Energy Supply and Environmental Coordination Act of 1974 to increase greatly the number of power plants that can promptly be converted to coal.

With the exception of the investment tax credit (which will be paid for by taxpayers rather than ratepayers) and the modification of appropriate environmental regulations, implementation of the energy proposals enumerated above will increase the cost of electricity.

A report released by FEA on January 23, 1975, entitled "The Impact of the President's Proposed Energy and Economics Program on Net Energy Costs to Consumers," takes cognizance of the inevitable increased electricity prices which will result from the Administration's proposed energy program, and estimates, as indicated in the following schedule, that the average residential electric bill nationwide during 1975 will climb about $13, or some 6 percent.

ESTIMATED INCREASE IN 1975 AVERAGE RESIDENTIAL ELECTRIC BILLS RESULTING FROM ADMINISTRATION'S PROPOSED ENERGY PROGRAM

Region	Increase Per Customer (dollars)	(percent)
New England	17.41	7.4
Middle Atlantic	10.29	4.4
East North Central	3.55	1.6
West North Central	12.61	5.6
South Atlantic	12.69	4.9
East South Central	4.59	2.0
West South Central	36.84	15.0
Mountain	10.78	5.2
Pacific		
Contiguous States	15.16	8.2
Alaska	46.64	13.9
Hawaii	26.29	9.5
Total United States	12.86	5.6

In spite of the FEA document's title, the Investigative Staff determined that the calculations utilized by FEA in its preparation take into account only the Administration's excise taxes and deregulation proposals covering petroleum and natural gas. Interestingly, FEA's estimates do not include analyses of other effects (mentioned later in this report) which would be associated with implementation of the proposed program. Consideration of only natural gas and petroleum impacts in these computations understates the real cost of the total program to consumers and, thus, is misleading.

To explain further the significant regional variations apparent in the foregoing table, there follows a tabular presentation of regional oil and natural gas use and the FEA-estimated effects such use will have on the cost of electricity in 1975 to consumers.

ESTIMATED INCREASE IN 1975 REGIONAL RESIDENTIAL ELECTRIC UTILITY RATES DUE TO HIGHER FUEL PRICES RESULTING FROM ADMINISTRATION'S PROPOSED ENERGY PROGRAM

Region	Percent Generated from Oil 1/	Percent Generated from Natural Gas 1/	Average Cost Increase (Cents/Kwh)
New England	68	0.7	.27
Middle Atlantic	35	3.0	.17
East North Central	4	3.0	.05
West North Central	2	29.0	.17
South Atlantic	26	6.0	.13
East South Central	2	4.0	.04
West South Central	6	87.0	.39
Moutain	5	21.0	.14
Pacific			
Contiguous States	19	19.0	.19
Alaska	12	57.0	.51
Hawaii	99	-	.35

1/ Based on 1973 fuels usage.

FEA officials noted that, with implementation of the Administration's energy proposals, old domestic oil (or about two-thirds of the U. S. crude production), now $5.25 per barrel, and new domestic oil (from wells placed in production since 1972, as well as oil production from old wells at levels above their 1972 production), now $10.75 per barrel, will both rise to the current world price of $11. Addition of the recommended $2 excise tax will move the price of all oil to about $13 per barrel. The 1975 price of natural gas is expected to increase very little as a consequence of proposed deregulation since only small amounts of "new" gas are expected to be available this year; natural gas cost increases will mainly be the result of the proposed excise tax.

An FEA representative revealed that his agency's analysis of the Administration's proposed energy program included the neutral assumption that coal prices will be unaffected by other fuels' price changes. The realism of this assumption must be questioned. Several utility and regulatory agency representatives told the Investigative Staff they are certain the Administration's proposals would indirectly raise the price of coal. Such an increase could result from 2 factors.

First, as conversion proceeds from natural gas and oil to coal burning power plants, new demands will tend to force coal prices upward. Second, and more important in the short run, are the attempts now underway by the coal industry to achieve coal prices equivalent to oil prices on an energy-content basis. To date, the coal industry has not been totally successful in its efforts to achieve this goal. It seems quite possible, however, that as oil prices increase, so will the cost of coal, though not necessarily to the point of equivalency.

While the prospects of coal prices rising may be debatable, there are other proposals included in the Administration's program (not addressed in the foregoing FEA estimates) which, if implemented, can be expected to cause higher electric rates.

Probably most significant is the expected recommended change in state utility regulatory rules to permit universal inclusion of construction work in progress in a utility's rate base. In 1973, according to information made available by FPC, 25 states allowed inclusion of this item in one form or another. As noted earlier in this report, the chairman of the FPC, in September 1974, indicated that full implementation of this policy option would have the immediate impact of increasing consumer rates about 11 percent.

A more benign estimate in this regard of about 8 percent was provided to the Investigative Staff by an FEA representative. (FEA officials are of the opinion the 11-percent figure mentioned represents a maximum since construction work in progress is now being computed in some rate bases.) As with many electric utility statistics, wide regional variations are inherent in these estimates. Some state regulatory officials have reported such a regulatory policy change could trigger cost increases to consumer of from 7 to more than 20 percent.

Two additional proposals designed to speed utilities' collections of needed revenue are expected to be contained in the Administration's energy program. One would recommend wider application of the automatic fuel adjustment clause to include all states. This device would not cause a net increase in rates, but it would pass on fuel costs to some customers even more rapidly than is true now.

The second will propose to speed up the imposition of rate increases by encouraging regulatory commissions to approve new rate requests subject to

refund prior to a final decision being handed down in the matter. Under present regulatory practices, it is not uncommon for a utility to wait one year before a requested rate increase is approved. Under the proposed procedure, rates could become effective almost immediately after a utility's filing. For the utilities this means rate relief would not be eroded by inflation by the time new rates became effective; for the consumer it would mean a one-time "catchup" increase in rates, a substantial sum, industry representatives admit.

Although the Administration had not formally submitted its proposed amendments to the Energy Supply and Environmental Coordination Act of 1974 at the time this report was prepared, it is generally expected they will include relaxation of certain emission standards to permit power plants to burn higher sulphur coal. The FEA analysis of price impacts did not include the costs and benefits accruing to consumers from conversion of natural gas- and oil- to coal-fired power plants because this is expected to be a minor item during 1975. FEA estimates that, if there is implementation of the proposed environmental amendments, 9 generating plants with a capacity of approximately 3,116 megawatts will convert during 1975. This is an increase over the 5 plants with 2,038-megawatt capacity which are expected to convert in 1975 without the impetus of environmental regulations revisions. The conversion increment represents less than 1 percent of the industry's installed generating capacity. Nevertheless, according to FEA officials, any conversion will tend to reduce rates; they calculate utilities will effect a net savings from conversion, of more than a $2 a barrel equivalent.

In summary, it appears that FEA's estimate of the increases in electricity prices stemming from the Administrations's proposals is low. Assuming that

coal prices remain steady, that benefits from conversion to coal are negligible in 1975, but that state regulatory commissions and the FPC act on the Administration's proposals, prices, on the average, could rise 14 percent or more--a 6-percent fuel increase plus at least an 8-percent increase for earnings on construction work in progress.

This is a conservative estimate. It is important to remember that the possible rate increases noted here are only those which would be added to underwrite the impacts on electricity prices which would attend implementation of the Administration's energy program. The increased numbers of rate filings already experienced by regulatory commissions indicate that prices can be expected to rise in 1975 whether or not the Administration's proposed national energy program further inflates the cost of electricity to the consumer.

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APPENDIX I

COMPOSITION OF FEDERAL POWER COMMISSION REGIONS BY STATE

Region	Composition
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic	New Jersey, New York, Pennsylvania
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska North Dakota, South Dakota
South Atlantic	Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West South Central	Arkansas, Louisiana, Oklahoma, Texas
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific	
Contiguous	California, Oregon, Washington
Noncontiguous	Alaska, Hawaii

Mr. WHITTEN. Among other things, we asked the effect of various things, including the action of EPA and requirements for this, that, and the other. I would like to see that put in the record plus any updates.

My purpose in this would be to ask if they could supply us with any additions once you see this, of anything else the committee might check so we can bring it together in one package.

I wrote the original request. It was submitted to all the various subcommittee chairmen and ranking members on the committee joined in that.

May I say the Secretary of the Interior said he had read my book written in 1966 and claimed I was an environmentalist. I said I am. That is why I refer to these as extremists but not environmentalists. The reason it costs gas-guzzlers about 20 percent are the gas guzzling requirements of the EPA; about 20 percent of the cost is by reason of Government regulation.

Vaccinations based on giving people slight doses of this and to weaken strains and letting the body build up resistance. In this I point out man, when he first lived, defined his cave. He had to match discomfort from the smoke against heat. Now it looks like we are getting even colder so we have to move further outside the cave. This is oversimplified.

It bothers me. A whole lot of the message is in consideration of the environmental extremist. If we give up the breeder reactor, they in turn will go along with the rest of it, but the rest of it comes because of the requirements we have imposed on ourselves. With scrubbers in the manufacture of electricity, you have 160 square miles that will be sunk in sludge for about 6 feet deep to take care of it.

Way back when I did a study on matter, I learned you can't change the sum total of matter; you can change its content but when you get through you have the same total. I wonder if we haven't gone off on a binge. You remember a few years ago everybody was upset about beautification. I am all for it but the key to it was the President's wife, Ladybird Johnson, started talking about beautification. Now we just don't hear about it.

I am just raising these points. The Government and the people, are going to have to decide whether a little discomfort might not strengthen us to meet greater discomfort in the future—so if we could ask the department to supply us with anything that we have overlooked in this investigation I would appreciate it.

Mr. FRI. I will try to do that.

[The information follows:]

REVIEW OF ENERGY SURVEY REPORT BY DR. LIVERMAN'S ENVIRONMENT AND SAFETY OFFICE

In response to your request, my office has reviewed the document entitled "Energy Survey" (David A. Schmidt, Director, Surveys and Investigations Staff, House Appropriations Committee). Although our review has focused on the environmental information, our comments enclosed will also touch on other information presented in the document.

In general, we feel that the relevancy of the 1974 Staff Report suffers from the rapidly changing political, economic, technical, and regulatory environment

relating to energy production and utilization. Therefore, usefulness of the report is limited without considerable updating. In fact, in recognition of the need for a comprehensive up-to-date evaluation of the environmental implications of generating electricity from coal, I made the following statement to the House Committee on Science and Technology 2 years ago (July 30, 1975):

"* * * I have become convinced that the Assistant Administrator for Environment and Safety must continue developing a comprehensive understanding of the issues related to coal combustion, and an independent assessment regarding the associated environmental control technology requirements and assessments of proposed evironmental control systems. These assessments must include consideration of all alternative systems and be based on sound environmental, engineering and economic judgments. I shall undertake to conduct the initial assessments at the earliest possible date with a view toward providing a continuous assessment of the control strategies as ERDA's programs develop."

During the intervening period, we have produced a balanced program plan document which outlines many of the problem areas; we have produced 35 preliminary and five pilot Environmental Development Plans which outline, in detail, the problem areas in the technologies; we have initiated a major study, "National Coal Utilization Assessment" which looks at the impacts of coal use in all regions of the United States. Finally, we recently have initiated a detailed environmental analysis of the comparative risks of all energy scenarios in the ERDA national plan for energy research, development, and demonstration.

Preliminary judgments based on information generated as a result of our initiatives in this area are expected in late calendar year 1977.

Review of "Energy Survey" by Office of the Assistant Administrator for Environment and Safety, U.S. Energy Research and Development Administration

In general, the 1974 document suffers from a lack of current information. This is manifested in the discussion on environmental regulations and costs; however, it is particularly evident with regard to conclusions dealing with energy policy. For example, concept of peak-load pricing is strongly supported throughout the report as a means of reducing the need for new generating capacity and better utilizing existing capacity. Although, utilities are generally characterized as opposed to this idea, this is no longer entirely true since several utilities have recently been actively studying methods for implementing such a scheme. A dramatically lowered growth rate for demand is also implied, with the extremely low value for 1974 noted (page 126). However, since that time, demand has again picked up. The Edison Electric Institute reported an overall increase in generation during 1976 of 6.3 percent which approaches the historical value of about 7 percent.

The relevancy of the discussion on environmental regulations is limited by the 1974 issues addressed. Since this area represents a rapidly changing one, the implications of a number of recent developments must be incorporated into the discussion for balance. These developments include:

(*a*) The consideration by EPA of stricter standards for NO_x emissions from utility boilers (levels of 200 ppm for 1980 and 100 ppm for 1985 are targeted as research and development goals).

(*b*) The possibility that ambient air quality standards in addition to those now existing will be promulgated. (An ambient standard for lead is currently under consideration.)

(*c*) The recently established EPA policy on the location of emission sources in nonattainment areas which could restrict the siting of new facilities.

(*d*) The proposed Clean Air Act amendments requiring the prevention of signification deterioration of air quality in areas currently meeting secondary ambient air quality standards.

(*e*) Other Clean Air Act amendments before the 95th Congress which could markedly affect the deployment of control equipment, for example, the requirements of flue gas desulfurization systems on all new coal-fired powerplants.

The costs for power plants and related equipment are also rapidly changing and should be updated. One recent set of estimates by Bechtel may help to place

the situation in perspective. For operation in 1986, the capital costs (in 1977 dollars) are:

1. Three 700 Mwe oil fired units—$600/kW.
2. Three 700 coal fired units using high Btu Eastern coal with flue gas desulfurization—$910/kW.
3. Two 1100 Mwe nuclear LWR's—$1,100/kW.

The discussion on particulate control focuses on electrostatic precipitators which are currently used extensively by the industry. New technology related to fabric filters may provide a promising alternative in the near future.

Control costs for NO_x were not reported. For perspective, the installation of the necessary equipment for staged combustion is estimated at $0.50/kW on a 500 Mwe existing boiler and at $0.14/kW for a new unit (1973 dollars).

The document discussed flue gas desulfurization costs in some detail. Since 1974, much emphasis has been placed on precombustion control (coal cleaning) as an alternative to post combustion (flue gas desulfurization) systems. For example, a recent Department of Commerce study estimated that precombustion cleaning to meet emission standards would demand (in the Northeastern United States) a 0.5 to 2 mill/kWh increase in generating costs as compared to a 4 to 6 mill/kWh cost for flue gas desulfurization.

The staff report gives the energy penalty for flue gas desulfurization (scrubbers) as 4 percent.[1] This is about right for lime/limestone throw away systems, but the penalty may be as high as 10 percent for regenerable systems now under consideration. Capital costs for scrubbers on a 500 Mwe plant burning 3 percent sulfur coal are estimated at $70–100/kW. At a load factor of 0.75, this adds 4–5 mills/kWh to generating costs. Since this represents about 20 percent of the busbar power costs, the figure of 7 percent for environmental controls quoted in the report appears low.

EXAMPES OF ARBITRARY OR UNSOUND ADMINISTRATIVE ACTIONS UNDER EXISTING FEDERAL LAWS

1. Tellico Dam

Completion of this $100 million TVA project is being delayed and may be fully halted by claims of a threat to the survival of a recently discovered three-inch long obscure fish—the Snail Darter—which inhabits a seventeen mile area of the Little Tennessee River destined to become part of the dam's reservoir, despite the fact that these Snail Darters have been transplanted and despite the imperative need for the additional power which it would provide to the seven-State region it serves.

2. Endangered species laws

It is most disturbing to find that a relatively unimportant and until recently unknown species of fish can be used to stop completion of a valuable national asset and a potential source of much-needed power. Now it would appear there may be no sound basis to term it an endangered species. It is even more disturbing—and even frightening—to learn that an ever-increasing number of insignificant species of plants, animals and other forms of life—many searched for and found for the purpose of blocking public works projects—are being declared endangered and thereby being used to threaten and sometimes stop further development of major sources of waterpower, fuel, food, and fiber in other areas of the country.

3. Blacklisting by EPA

The Environmental Protection Agency is blacklisting or threatening to blacklist various industrial plants, thereby making them ineligible to bid on future government contracts, as a means of forcing compliance with EPA air and water pollution edicts, even though such plants have not been legally determined to be in violation of antipollution laws. The threat to our industrial establishment from this administrative practice is serious.

4. Seabrook nuclear powerplant

Completion of the $2 billion Seabrook nuclear powerplant in New Hampshire is being threatened by those who object to the use of ocean water for its cooling system, despite the serious shortage and excessive cost of fossil fuel to generate

[1] This does not include energy penalties for acceptable solid waste management practices.

power in the energy-deficit New England area and the urgent need to develop alternative sources of power for the future.

5. EPA restrictions on national defense activities

Even the Department of Defense—the Army, the Navy, the Air Force, and the Marine Corps—are subject to EPA restrictions which require environmental impact statements in advance of the conduct of military maneuvers—so essential to our military defense readiness—and alo require the sacking of body waste involved in such maneuvers—even in remote areas. Truly such use of power endangers the Nation itself.

6. EPA stoppage of automobile production

Recently, the EPA ordered the Ford Motor Co. to stop production at several of its plants, reducing the output of about one-third of certain of its models. This was done, despite the adverse affect of such order on the unemployment problems presently existing in such areas.

7. Restrictions on the use of coal

The Clean Air Act Amendments of 1970 require that sulfur dioxide emissions must be controlled to the extent necessary to protect the public health and welfare from adverse effects of sulfur dioxide. EPA in developing the regulations has chosen scrubbers rather than other less costly alernatives—alternatives that would fully protect the public health and welfare while at the same time saving the public billions of dollars on their utility bills. In fact, one EPA study estimated that scrubbers would increase the cost of electricity to the consumer by 17 percent.

8. Storage of oil reserves

According to committee hearings, it took 13 months to get permission from the Environmental Protection Agency to use a hole in the ground to store reserve supplies of oil.

9. TVA pollution ban rejected

TVA erected two 1,000-foot high smokestacks in view of EPA ground level standards. EPA later said these were inadequate since the pollution at the level of emission, not at ground level. An estimated $245 million to $400 million of additional cost to taxpayers is involved in order to obtain compliance.

10. Oil divestiture ordered

A district court in New York has ordered FTA to prepare an environmental impact on oil refineries and proposed divestiture of refining operations and pipelines with formation of 10 to 13 new refining firms.

11. Elevator for handicapped (city hall New York City)

City had to conduct environmental review. EPA warned of "potential for noise" and "suspended dust particles." Under 1974 Community Development Act there must be an environmental review of every project funded thereunder. In New York City there have been 60 such reviews thus far for about $130 million in community development projects. Typical review takes 12 to 15 man-weeks of salaried time. In no case has an impact study been found necessary. Council for Environmental Quality—White House watchdog—admits that there is a flaw in the regulations.

12. Dickey-Lincoln project

This project on Maine's Upper St. John River stalled over plant called "Furbish lousewort."

13. Kaiparowits coal-fired electric plant

This plant was dropped by utility companies. During the 13 years of delay on environmental grounds, costs increased sevenfold to $3.5 billion. Paperwork cost utilities $5 million. Project would have threatened "Black-footed Ferret" and "Kangaroo Rat," and allegations of possible air pollution impact.

14. Oil wells and beaches

A New York court has been holding up oil and gas drilling off the East Coast on the basis that planning is inadequate under EPA standards. Benefits of stable fuel prices versus environmental protection are involved. Atlantic States have opposed offshore drilling, yet at the same time they resent rising fuel costs.

15. Environmental impact statements in Mexico

Under EPA regulations USDA must file expensive and time consuming environmental impact statements, even for insect control programs conducted in Mexico to prevent spread into the United States.

16. Control of fire ant

This is a good example of problems with EPA on insect control measures. Farmers are permitted by EPA to use bait—Mirex—only once per year. Yet it takes two treatments per year to be effective. Both the money and effort of the once per year application are wasted on this basis.

17. Control of cotton gins by OSHA

Technological advances have permitted great progress in recent years relative to the improvement of working conditions in the Nation's cotton gins. However, the Occupational Safety and Health Administration (OSHA) has placed all cotton gins under arbitrary and unrealistic cotton dust exposure standards involving pulmonary function tests for all new employees and additional tests after 10 hours or less on the job. The added expense involved will cause many of these gins to go out of business, with resulting unemployment throughout the Cotton Belt.

18. Farm pamphlets issued by OSHA

Last year, at a cost of some $500,000 of Federal funds, OSHA issued 1.5 million copies of 28 pamphlets explaining the dangers of farming and prescribing new safety rules for farmers and farmworkers. These documents contained the following advice: "When floors are wet and slippery with manure, you could have a bad fall." The regulations contained in these pamphlets require any farm with five or more employees to have a toilet within 5 minutes walking distance of where employees are working in the fields—in effect requiring numerous stationary facilities and/or portable toilets on farms of any size. These pamphlets also establish the requirement that every farm tractor must be equipped with seat belts and roll-over bars. In addition, they place on the farm operator the unrealistic and unenforceable responsibility of insuring that each farm worker use seatbelts whenever a tractor is moving. These are impractical requirements in view of the methods used in driving farm tractors and the limited danger involved. It is apparent that these regulations were prepared by persons with no actual knowledge of agriculture and little or no realization of the adverse effects such requirements have on the ability of the average farmer to stay in business.

19. OSHA regulations on ladders

Voluminous regulations pertaining to the construction, use and safety of ladders have been issued by OSHA. A total of 74 pages of the Federal Register are devoted to this subject. Included are such definitions as: "A ladder is an appliance usually consisting of two side rails joined at regular intervals by crosspieces called steps, rungs, or cleats, on which a person may step in ascending or descending" and "Steps are the flat crosspieces of a ladder on which a person may step in ascending or descending." Since ladders have been used by mankind throughout history, the extensive definition and regulation of such a commonplace appliance used frequently by many people would appear to be an activity for which OSHA might be able to show substantial budgetary savings.

EPA ENVIRONMENTAL STANDARDS

Mr. YATES. When you talked about the EPA standards were you referring specifically to oil shale or the whole field of energy?

Mr. WHITTEN. The whole field.

Mr. MCKAY. I think there is an example of what you are trying to get at. I believe it is in Ohio where they are building a coal generation plant to use low-sulfur coal and they were meeting environmental and air standards without scrubbers, but EPA demanded that every new plant had to have scrubbers.

They installed scrubbers and now they have had to induce as much sulfur as they have in the coal just to get them to work. I think that is what you are talking about.

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The rule is so rigid it doesn't apply some horse sense to circumstance.

Mr. WHITTEN. I would like to put in the record an illustration that just came to my attention. EPA requires the Marine Corps if they want a maneuver to file an environmental impact statement. The last one cost $40,000. They also have a rule if they have maneuvers in the most sparsely settled area they have to take a receptacle around for the body waste. When you get through with EPA and you take your own Department with endangered species——

Mr. YATES. What is your list on ERDA?

Mr. WHITTEN. On ERDA, that is why I am asking them to help me. When they tell me, then I can believe it.

We did need to bring all this together. It is frightening if we ourselves are bringing our standard of living down. The question is: Is it necessary or is it just desirable for a relatively few people?

Study the field of vaccination. It is all based on toughening yourself. If you are going to be a distance runner you toughen yourself to it. We are working in the other direction. Where we are hothouse plants, can't stand loud noise, bad odor. If we succeeded, the first time a new germ got loose it would wipe us out. You don't believe that, but I do.

Thank you, Mr. Chairman.

ERDA OIL SHALE APPROPRIATION

Mr. YATES. Let's come back to oil shale for a minute. You are moving up. I notice your—your operating expenses appropriation for oil shale—appropriation for oil shale has been increased by $5,722,000 to $28 million and I wondered whether you had really made enough available for it. In Dr. White's testimony before the Senate in November, which is in the record of our overview hearings Wednesday: "without Federal help there will be no commercial shale oil plants on stream between now and 1985," and later "oil shale production is closer to commercial production than other liquid fuels alternatives." "Oil shale technology is technically simpler than coal liquefaction technology" and other positive statements. Finally, you say that "the Federal Government must: (1) lease shale lands, (2) provide the economic setting within which an industry must operate, (3) ameliorate environmental problems, (4) support development of new technology, and (5) promote the operation of selected shale processing facilities on public lands."

Is there a Government program to do all this? That is the question that came to my mind.

Mr. FRI. I can't comment on the leasing part of it.

As to the rest of it, the economic setting is one thing that will be heavily influenced by how the President's energy plan comes out of the Congress. But if the economics of shale oil are as I described them a few minutes ago, I think that will be a substantial stimulus to production. I have gotten some indications from the private sector that will be the case.

Mr. YATES. Is there enough money in your budget for oil shale?

Mr. FRI. I believe there is.

PRIVATE INDUSTRY VIEWS ON OIL SHALE

Mr. YATES. You think there is. The impression from these witnesses is that oil shale is ready to go and as a matter of fact I wonder whether ERDA isn't holding it up.

Let me give you the testimony of Mr. Schora. He came in from IGT. He talked about the commercialization; they are ready to go.

Mr. YATES. What do you mean by commercialization?

Mr. SCHORA. Basically the production of oils in a sufficient amount to have some unique impact on the supply of oil.

Mr. YATES. What would that mean in terms of quantity?

Mr. SCHORA. About 50,000 barrels a day.

Mr. MCDADE. What about price?

Mr. SCHORA. Right now, roughly we calculate we are talking potentially $15 to $20 per barrel. We think we are quite conservative on this. That is with eastern shale. With western shale we think we are more in the range of $10 to $15.

Mr. YATES. For western shale?

Mr. SCHORA. Yes, sir.

ERDA REACTION TO IGT OIL SHALE PROPOSAL

Mr. YATES. Where have you been? Why haven't you been talking to Dr. White?

Mr. SCHORA. We have.

Mr. YATES. What does he say?

Mr. SCHORA. The situation within ERDA basically is that the people that are now governing or looking over the oil shale work are pretty much involved in situ retorting operations and basically have the feeling that there is nothing new to be learned with the above-ground retorting.

Mr. YATES. Haven't they seen your work?

Mr. SCHORA. Yes; they have.

Mr. YATES. Your statement impresses us. Why wouldn't they be impressed as well? Is it because they know more than we do?

Mr. SCHORA. No; I don't think so. We have talked to Dr. White and some his people. Their comments basically are that the funding is not available for above-ground retorting, that they are pushing hard in situ western shale, that we could come up with potentially a much better process than what is now being pursued.

Mr. MCDADE. You did say you processed your work either above-ground or in situ.

Mr. SCHORA. We actually run it in a retort above-ground.

Mr. MCDADE. In a laboratory?

Mr. SCHORA. Yes, sir. Calculations indicate it would work in situ.

Mr. MCDADE. And you still got no relief at ERDA?

Mr. SCHORA. That is correct, sir. They know of this, but nothing has happened.

Mr. YATES. How much money did you ask for?

Mr. SCHORA. For the first year, roughly $2.8 million. Right now we are being funded about $700,000 to $800,000 a year by the American Gas Association. They went into this program on the basis that this is a good way to make gas.

Mr. YATES. Can you make gas out of it?

Mr. SCHORA. Yes, sir—depending upon the severity of the retort.

Mr. MCDADE. What is the gas price?

Mr. SCHORA. Equivalent gas price would be about $3 to $4 a thousand cubic feet.

Mr. MCDADE. My people who had to go to propane during the crisis paid about $4, as I recollect. Isn't that correct?

Mr. SCHORA. Yes, sir.

Mr. MCDADE. You are saying you believe with eastern or western shale you could produce natural gas at $4.

Mr. SCHORA. Yes, sir.

Mr. MCDADE. About the equivalent of propane?

Mr. SCHORA. Yes, sir.

Mr. YATES. In 8 years.

Mr. SCHORA. When I say 8 years, I say 8 years on the basis that we are essentially on a wartime footing; in other words, that things can be done.

Mr. MCDADE. We have been told we are. What is the cost? Give us the figures. Suppose we would say to you how much would you need to prove this out. We don't want you to be negligent with dollars, of course. We want you to go through the usual steps. But to get to it in 8 years, what would it cost?

Mr. SCHORA. We estimate roughly $100 million. We have gone through the figures.

But that is true of any oil shale development as a minimum, wouldn't you think?

Mr. FRI. Yes, at least.

DEVONIAN SHALE

Mr. MCDADE. My memory won't tell me what happened to the money we put in the bill last year for Devonian shale.

Mr. YATES. Dr. White said it was too tough a process, and I don't think any money went in.

Dr. SCHORA. There are two things going on with Devonian shale. One is the work on drilling and trying to extract the tight gas. The other is work being done in Michigan on in situ production within the shale, to try to produce a low Btu gas. My understanding is that work is going forward. But that is considerably different technology than what we are talking about.

Mr. YATES. Is this a patented process?

Mr. SCHORA. The patents have been assigned to the American Gas Association. Yes; there are patents on it.

Mr. YATES. What will you accomplish with the $2.8 million appropriation?

Mr. SCHORA. We are basically funding from the American Gas Association. What we would accomplish is to move forward on the further work with retorting various eastern shales and in the preliminary design of the pilot plant which we think is a step to commercialization.

PROPOSED IGT OIL SHALE PILOT PLANT

Mr. YATES. Do you have to do that in order to go to commercialization?

Mr. SCHORA. The pilot plant—I would say yes, sir.

Mr. YATES. How much will the pilot plant cost?

Mr. SCHORA. The whole program that we talk about, about three years, about $2.8 million, and then the pilot plant—the overall program is about $100 million.

Mr. YATES. That is going to commercialization. That is a demonstration plant.

Mr. SCHORA. What we are talking about here is the usual ERDA procedure, to go to a pilot plant, to a demonstration plant, and then to commercialization. If you go that route, you cannot possibly do anything under 12 years, simply because of the time it takes to build the plants. What we are talking about here is a potential of building based on the PDU we have in Chicago, which costs in excess of $1 million, a large pilot plant, and then to go to commercial.

Mr. YATES. What is the advantage of a commercial plant that produces only 50,000 barrels a day? That isn't enough really to satisfy a commercial need; is it?

Mr. SCHORA. No. But I think basically it would be marginal and would stand on its feet from an economic standpoint.

Mr. YATES. Isn't that true with Paraho today? Paraho has a process by which that is done.

Mr. SCHORA. That is correct, sir. I think the problem that stands in the way of Paraho is that it is the uncertainty of the future oil prices.

Mr. TARMAN. Also the Paraho demonstration plant does not produce 50,000 barrels a day.

Mr. MCDADE. But there is a proposal to try to do that. The Navy is going to run 50,000 barrels this year.

Mr. SCHORA. But not on a daily basis.

MICHIGAN DEVONIAN SHALE DEVELOPMENT

Mr. MCDADE. I have to ask you something further. You mentioned two projects that we are working on in Devonian shale. One is to try to get locked-in gas. That gas is there—and that is to relieve the natural gas shortage. I don't know who is doing that.

Mr. YATES. Is my memory right on Devonian shale?

Dr. WHITE. No, I don't think I said that about Devonian shale programs in general. However, it is our feeling on the specific proposal of IGT.

Mr. YATES. I thought Mr. McDade asked you about Devonian shale because he was very much interested in it.

Here is what he said about Devonian shale:

Mr. SCHORA. That is Columbia Gas.

Mr. MCDADE. ERDA is working on that process. And then there is the process in Michigan which does what?

Mr. SCHORA. The process in Michigan basically is to put holes in the ground, to join these holes by fracturing the shale, and then initiating combustion underground to produce a low btu gas, which could then be brought to the surface and burned as a boiler fuel.

IGT OIL SHALE PROCESS

Mr. MCDADE. Then we have the Paraho and the projects out West. Somewhere in the middle of this comes your process. Tell me how it fits in and how it is different.

Mr. SCHORA. Uniquely where it is different is that we in fact, rather than simply thermally retorting, we retort in the presence of hydrogen. What happens is that the kerogen rather than cracking and going to coke, there is hydrogen, and you wind up with a much lighter oil which is this material here. Now, uniquely, this material—we have with the assistance of some oil companies done some further work on this, very light hydro-treating and separation of the nitrogen materials, and you can make very high proportions of JP–5 with this particular oil.

Mr. TARMAN. In one of the presentations here——

Mr. MCDADE. I don't want to become an engineer in 5 minutes. It's not going to work. I am just—go ahead.

Mr. TARMAN. If you apply the conventional retorting, Paraho, Occidental, whichever, to an eastern shale, you will recover somewhere around 35 percent of the energy. If you apply our process, you can apply up to 85, 90 percent.

Mr. MCDADE. That is the new system that you have found.

Mr. YATES. You still cannot get Dr. White to help you out?

Mr. SCHORA. We have his ear. He is sympathetic. We have presented arguments to him.

Mr. YATES. More importantly, do you have his purse?

Mr. SCHORA. No, sir, we do not.

IGT COAL GASIFICATION WORK

Mr. MCDADE. Let me ask you this. Your shop is also doing the pilot plant on gasification. Is Dr. White looking at you and saying—you are doing it, you are successfully producing gas out there, aren't you?

Mr. SCHORA. Yes, sir. From coal.

Mr. MCDADE. Is he looking at it and saying "We have a process that our people are developing and we don't need this"—or what is the problem?

Mr. SCHORA. We are a little confused about what the problem is. From talking, when Dr. White sends us to the oil shale people, the oil shale people in Laramie, basically are totally dedicated to in situ work. They say that the environmental problems in the west are far too severe, that it has to be done underground. We stated this process may apply underground. They say "This is all very interesting, but we don't have funds for it."

Mr. MCDADE. Let me take you back to the Devonian shale, where you say you can work there and increase the yield of the energy substantially by using your new process. Is that an aboveground process, too?

Mr. SCHORA. That would be initially we propose aboveground, using outcrop shale. We would then essentially propose to study the concept for in situ work as well.

That is a demonstration project.

ERDA FUNDING FOR OIL SHALE DEVELOPMENT

They talk about various other things. The question in my mind as I listened to the testimony is why ERDA wasn't helping them. The testimony is that ERDA says, "We don't have money to help you." Is this

not an activity or an initiative that seems to be so constructive as to warrant ERDA funding? Am I overimpressed by this?

Mr. FRI. May I make a general response to that before Dr. White makes a specific one?

Mr. YATES. Sure.

Mr. FRI. I want to say two things. With the onset essentially based on the program we inherited from the Department of the Interior, our program has been directed toward in-situ technology. The general belief was there were three surface retort types that had to be developed essentially to a pilot plant stage and that the next step was to run a full-scale module. That effort should not be funded from our technology development budget, but rather should be supported from the proposed alternative fuels demonstration program.

It may be that there are new surface processes that ought to be looked at now. This process didn't come to my attention until Mr. Linden of IGT sent me a copy of that testimony a few weeks ago. The estimate that I remember from that testimony was gas at $3.50 to $4 per million Btu. We are working on processes in Devonian shale, and in geopressurized zones of the gulf coast, which if they work, will have prices more in the $2.50 to $3.25 range. So while we may be paying $4 for propane, maybe we can find something better. It goes back to the priorities you were mentioning earlier.

Mr. YATES. What you are saying is we don't have enough money to try both of them?

Mr. FRI. We don't have enough money to try everything in every field. We do have to set some priorities.

I am just trying to put the particular set of prices included in your recitation of the testimony in the context of the other technologies on which we are working.

As to the feasibility of the technology, how much it would take to develop it, I think Dr. White is in a far better position to comment than I.

Dr. WHITE. Our feeling is not a case of not having enough money to support promising technology. Their process isn't that promising. It is very well known that hydrogen does give you a higher yield, but it is not one that is unique with IGT. I think every company working in shale has tried it at one time or another and found it does produce more material. On the other hand, you do have to use a certain amount of that material to generate the hydrogen. It does turn out to be more expensive to proceed with it than normal retorting.

It may eventually look more attractive as we learn more about the final economics of retorting, but I would not expect it to have a large advantage in production of liquids.

We would say in terms of the national interest it would be very unsound to use a material with a very fine liquid potential, like western shales, to produce gas. IGT has worked on this but it has not been one that we felt was appropriate to pursue. When you get into eastern shales, it may be a good use of that resource to retort them above ground to get the gas out, because there is material that we are not going to get any other way. You can't get oil out of it. You may be able to get some gas out.

Mr. YATES. Are you talking about Devonian?

Dr. WHITE. Yes. After we take the gas that is locked up tight, it may be useful to mine it. I think that is going to be very expensive gas. We see now in some of these more expensive coal gasification places, probably somewhat later because production is going to be stimulated by higher prices from these exotic gas sources, all will probably come in before these $3.50 and $4 gases.

Mr. YATES. This testimony was to the effect with respect to the western shale the cost would be $10 to $15.

Dr. WHITE. Oil.

Mr. YATES. I am talking about oil.

Dr. WHITE. Yes. My testimony in front of the national hearings was in that same range.

Mr. YATES. $10 to $15.

Mr. WHITE. Yes.

Mr. YATES. Is IGT's process different from the other companies?

Dr. WHITE. Yes; it is.

Mr. YATES. The price for achieving its oil is in the same price range?

Dr. WHITE. I think if I remember what you said, they were really looking at the $15 to $20 a barrel.

Mr. YATES. Yes, on eastern shale; $15 to $20 on the Devonian shale.

Dr. WHITE. Is that it?

Mr. YATES. Is your other processing out West by other companies less than $10 to $15 a barrel?

Dr. WHITE. The figures given by Occidental for their modified in situ process are in the $8 to $11 range. I think they have to be taken with a certain amount of skepticism.

THE SUPERIOR FREE MINERAL PROCESS

Mr. ARMSTRONG. Could we ask about the Superior process, the free mineral process, that compared to what we have been discussing?

Mr. YATES. That is a new one.

What does that mean?

Dr. WHITE. In addition to recovering oil from the shale, this process also recovers some mineral compounds. These compounds are dawsonite, which can replace bauxite as a source of aluminum, and the other is nahcolite, which is a form of sodium bicarbonate which can be made into soda ash. But more importantly nahcolite can be used as a dry flue gas scrubbing material because it can absorb sulfur dioxide just by blowing it into the stacks. This is one of the things that is being looked at.

Mr. ARMSTRONG. The thing that is distinctive about this is that unlike the other companies the people who are backing this aren't asking for Government support. All they are asking is to cut the red-tape and let them try it. Superior claims this process is feasible, and once private financing is made available production can begin.

Mr. YATES. What is the Government doing to stop them?

Mr. ARMSTRONG. As I understand it at the present time, Mr. Chairman, the status is that it is tied up over at the Interior Department. Superior claims they are ready to start tomorrow and it will take 2 years just to get the paperwork processed, the EPA statements. I am only reporting what I have been told.

Mr. YATES. Do you know about this?

Dr. WHITE. Yes. Superior has a great deal of enthusiasm for this project using appropriate land. They have land holdings next to land that would be very good for this purpose. They have been trying to arrange a swap of the leases with Interior. Interior at one point thought this was not an unreasonable request and did start through this chain, and it has literally been 5 years.

Mr. ARMSTRONG. Wouldn't it be appropriate if the process has any promise and if they are willing to develop it, couldn't ERDA do something to encourage Interior to let them try it? It seems to me that is a very reasonable thing. If somebody wants to try it at their expense, why not let them try it?

Dr. WHITE. We have not approached the new administration at Interior on this subject.

Mr. ARMSTRONG. I don't want to lead the committee afield.

Mr. YATES. Secretary Andrus is coming in on Wednesday. I have asked the staff to advise the Secretary that we will be asking him about this question.

Mr. ARMSTRONG. In preparation for that I did want to direct the witness one additional question. How do you feel about the process? Is what they are saying plausible?

Mr. WHITE. It is a very promising process for the land that has these minerals on it. There is no question about it, it will probably be one of the first to go and is quite attractive economically. It uses a retort that is in commercial operation.

Mr. EVANS. Would the gentleman yield?

Mr. YATES. Mr. Evans.

Mr. EVANS. You did approach Secretary Kleppe. Could you acquaint us with the response of the Secretary?

Dr. WHITE. It was a very generalized approach. It was not directed specifically at the Superior matter but the shale leasing for in-situ work which had not moved very far in Interior. Kleppe said, "We hear you and we will look at it."

Mr. YATES. Had you completed?

Mr. ARMSTRONG. Yes. Thank you, Mr. Chairman.

PARAHO OIL SHALE PROCESS

Mr. YATES. Where are we on shale, then? Where is Paraho's process in the new plan?

Dr. WHITE. Paraho ran a program backed by private companies without any government support which established basically what was an operable retort. I think our people technically feel it is ready to go when someone wants to build a modular retort for commercial operations. There are discussions with the Navy to run the facility and produce some material for testing. The committee rejected our request, so we are taking a new look at what we ought to do.

Mr. YATES. Mr. McKay.

FUNDING AGREEMENTS BETWEEN THE FEDERAL GOVERNMENT AND PRIVATE INDUSTRY

Mr. MCKAY. The Navy had been playing around with oil shale for a number of years before it came to the attention of the public, but

there is a more basic question whether it is with oil shale or coal gasification. Are the agencies considering matching funding, or total funding?

What kind of arrangement? I have been given to understand by some who work in the field that there are companies, for example, in coal gasification and I assume the same thing would apply to oil shale, who if the Government were to go in with them on a commercialized venture right away the technology, as you indicated in some cases, is about ready to go, but they don't feel that they are ready to go privately all by themselves. If the government would come in 50–50, I am not sure what that would mean. There are companies who would join in that operation for commercialized plant knowing full well that the first plant probably would have too many bugs in it but out of it they would gain enough knowledge and experience that at that point the industry would take off on its own to build plants.

I think we have had witnesses and conversations last year to show that there are companies ready to go. Have you dealt with any of them or probed into those facets where we can move development more rapidly?

I fear—we had a little fight on the floor last year over this—we are at the point where we build so many model plants that we just go through them like crazy but we can't spin out of models. Somebody has to make a decision, OK, we are jumping out and we will modify it when we get there.

LOW-BTU GASIFICATION CONTRACTS

Mr. FRI. May I respond in part at least to that.

You break that down into three points; low-Btu gas, shale and high-Btu gas. In the case of low-Btu gas we have in the course of the past year or so awarded a number of contracts for what amounts to the commercial application of low-Btu gas on a cost-sharing basis with industry.

Mr. MCKAY. Is that commercial size?

Mr. FRI. Yes, but the commercial size is small.

We are also contracting for low-Btu gas demonstrations for a distributed system where the gas will be generated in one spot and distributed to industries within a fairly close radius. We are also contracting for low-Btu gas to be used to replace natural gas as chemical feedstocks in specific industries. Those are commercial sized plants.

Mr. MCKAY. Are they ongoing?

Mr. FRI. We are just in the process of letting those contracts.

Mr. MCKAY. When will they be let?

Mr. FRI. Some of them have been let. All have been selected and not all the contracts are signed yet.

Dr. WHITE. I think three of the small ones have been signed and are underway. The others are still in negotiation.

Mr. MCKAY. I would be interested in where they are.

Mr. FRI. We can provide that data.

PROJECT STATUS OF INDUSTRY GASIFIERS

Small-sized individual gasifiers are currently available and will be the first application of synthetic fuel conversion from coal in industry. The Government

involvement in this area is of short duration and focuses on the use of these gasifiers for caking coals and evaluating environmental safety. These projects will be heavily cost shared by industry. A recent PON called for proposals to achieve these objectives. Six proposals were selected for negotiation; these are summarized:

1. Land O'Lakes (with Applied Technology Co., a division of Black, Sivalls & Bryson) will use low-Btu gas for a boiler and a spray dryer for drying dairy products at Perham, Minn. A Wellman-incandescent gasifier with extensive particulate and condensable product cleanup will be utilized. Low sulfur coal will be used at a feed rate of 2 tons per hour. Total estimated cost is $7.2 million; ERDA's share is $3.6 million (50 percent).

2. The Glen Gey Brick Co. (with Acurex-Aerotherm) will instrument an available gasifier, which will fire a brick kiln at a small brick manufacturing plant in York, Pa. Data will be obtained beginning in September 1977 at minimal cost to the Government. A single-stage Wellman-Galusha gasifier without gas cleanup, feeding anthracite coal at 1 ton per hour will be used. Total estimated cost is $1.2 million; ERDA's share is $0.6 million (50 percent).

3. University of Minnesota (with Foster Wheeler Corp.) will use fuel for a boiler to provide space heat and steam to campus facilities at Duluth, Minn. A STOIC gasifier with particulate and condensable cleanup will be used. Low sulfur Wyoming coal will be fed to the gasifier at 3 tons per hour. Total estimated cost is $4.8 million; ERDA's share is $2.2 million (46 percent).

4. Irvin Industries (with Mason & Hanger Co., and the Kentucky Center for Energy Research) will use fuel in a 172-acre industrial park at Georgetown, Ky., for space heating, process steam, and direct and indirect fire applications. Included in the park will be a metal heat treating and metal finishing plant. Two Wellman-Galusha gas producers and the Holmes-Stretford process for desulfurization will be utilized. Eastern Kentucky coal with a high swelling index will be fed to the gasifier at a rate of 1.5 tons per hour. Total estimate cost is $5.6 million; ERDA's share is $2.8 million (50 percent).

Subject to conditions: (1) State funding approved, (2) 50 percent of gas produced must have contractually committed users on site, (3) zoning and environmental factors satisfied, and (4) all of above by a date satisfactory to ERDA.

5. General Refractories (with Holly, Kenney, Schott, Woodall-Duckham) will use gas to fuel refractory tunnel kilns, periodic kilns, and dryers at Hitchins, Ky. The refractory industry consumes 35 trillion Btu's of natural gas per year. A Woodall-Duckham (two-stage) gasifier with tar and dust cyclones will be fed low sulfur coal at 1.5 tons per hour. Total estimated cost is $5 million; proposed ERDA share is $3 million (60 percent).

Subject to condition that 50–50 cost-share target is achieved.

6. Pike County Industrial Commission (with Mason & Hanger and the Kentucky Center for Energy Research) will use gas in boilers for hot water/steam to meet heating and cooling needs of a planned community of housing, fire station, school, shopping and recreational areas in Pikeville, Ky. Later the system will be expanded to include an industrial park. Eastern Kentucky low sulfur coal will be fed to a Wellman-Galusha gasifier at 1.5 tons per hour. Total estimated cost is $6.9 million; ERDA's share is $3.8 million (54 percent).

Subject to conditions: (1) 50–50 cost share and, (2) inclusion of technical management.

The contractual arrangement to be negotiated in all cases is the cooperative agreement. To date two cooperative agreements (the University of Minnesota and the Acurex projects) have been negotiated. Both of these projects are in the design phase of the program. Preparations are being made for negotiations with the remaining four during the third quarter of fiscal year 1977.

COMMERCIALIZATION OF OIL SHALE

Mr. FRI. In the case of shale, the President's energy policy forces us to take a new look. Although I have not had contacts with all the people in the field, my initial impression is that if industry and utilities are looking at oil prices of the type the President has proposed, the private sector will be motivated to put up a lot of their own money to go ahead with those projects. The worry is not so much about the

capital as about the Arabs having a price war and cutting the price. You could solve that problem for the first couple of plants in a couple of ways. One is to put a floor under the product price for the first plant or you could line up the Department of Defense to buy it at a set price.

We are just going to have to go back and relook at that. I am more optimistic industry may move out pretty much with its own money.

STATUS OF HIGH BTU GASIFICATION CONTRACTING

Hight-Btu gas is a more difficult problem. We do have in its initial stages, and again we are ready to sign a contract for a high-Btu gas demonstration plant which uses commercial size equipment, but the plant itself isn't commercial size. We don't replicate all the gasifiers of an economic sized plant. The question of how to approach the high-Btu gas projects is something we are going to have to reassess in light of the new policy and we have not been able to do that yet.

MR. FRI'S ASSESSMENT OF THE ENERGY PROBLEM

Mr. YATES. Dr. Fri, let's have an energy interview. We have had the President's statement, we have had four statements within the past week. We had President Nixon's statement following the OPEC embargo or the Arab embargo in 1973 and his declaration that we were determined to be independent of foreign energy sources by 1980.

In the wake of that, Project Independence was organized and ERDA was organized and we had a reformation of the energy field. We had FEA in the picture.

Are we ever going to be completely free of dependence on foreign sources? What is your assessment of where we are, where we are going, and how long it is going to take us?

Mr. FRI. My personal judgment is it will be many years before we can be totally free of some dependence on foreign sources, perhaps until the end of the century. There are a few problems that we are beginning to discover that require a lot of liquid fuel, for example, feedstocks to industry, where it is just difficult to substitute anything else. Those are going to be tough problems to solve. I think there will have to be some continuing dependence on foreign oil.

We can, through an active petroleum storage program, ameliorate the prospect of an interruption in that supply and we are engaged in that. The President proposed doubling the size of the storage program. But I do believe that by the 1990's, if we do have an active conservation program, if we do have a successful storage program, and if we are successful with coal and with some of the new technologies, we will be substantially independent from foreign sources in the sense of not having an adverse balance-of-payments situation, of having a good deal of foreign policy flexibility, and not being subject to economic crises because of a cutoff.

ENERGY SCENARIO FOR 1985–1990

Mr. YATES. What do you see as our having achieved by the 1990's—would you itemize each of the categories and let us know where we will be, for example, in coal liquefaction or in coal gasification? Where

will we be in oil shale, in nuclear, in solar, in geothermal? We would appreciate your letting the committee know where we would be and how long it will take. You may give us an opinion off the top of your head.

Mr. FRI. This is a personal judgment. I think by 1985 to 1990 it is entirely credible we will have a conservation program that will have reduced the growth of energy consumption in this country down to around 2 percent, or slightly lower.

Mr. MCKAY. Two percent lower than where we are now?

Mr. FRI. Perhaps to a 1.9 or 1.8 percent growth rate. I think that is entirely credible. I think that gas and probably oil production in this country will still be at something like the production rates we see today. We can stave off the clock but we may not see vast increases in the supply of domestically produced conventional sources of oil and gas.

If our new technologies are successful, gases from the exotic sources, the tight sands, the Devonian shales and the geopressurized zones, there are quite substantial quantities of gas to be obtained. Low-Btu gas and coal will be a fairly commonly operated technology in particular areas of the country that are subject to interruptions or not handy to pipelines.

I think solar will have made a substantial impact in the commercial and residential sector for space heating and hot water heating. The President's goal of 2½ million homes with solar systems is a tough goal to meet. But by the nineties certainly a lot of market penetration will be made and that will be a big help.

My own view of geothermal is quite optimistic. I think we are going to be successful in the geothermal program and by the 1985 to 1990 period we will be producing electricity from geothermal resources in significant quantities particularly in the West. We will have the ability to install more capacity as we need it. That is terribly important because California is dependent on gas and oil and doesn't have any coal. So if we use geothermal in that region to produce electricity, we will be, I think, in very good shape.

Mr. EVANS. May I ask a question there?

Mr. YATES. Why don't we let him finish first.

Mr. EVANS. Fine.

Mr. FRI. I think that by that time we will have on board the first batch of shale oil facilities. Production will not be more than several hundred thousand barrels a day by 1990 if we are lucky, but there will be an established technology helping to close the liquids gap.

I think coal will in fact grow to around a billion tons a year in that time frame. It will be under fairly stringent environmental safeguards but I think the trick there is to have a set of environmental requirements and stick with them and not to be changing them all the time. The uncertainty as much as anything else drives industry crazy. At the present time, coal is not supply limited, it is market limited.

Finally, I think nuclear power in the form of the light water reactor, which is the current generation of reactors, will continue to grow and by the end of the century we will probably see something in the neighborhood of 300 to 400 light-water reactors in operation. Just how many there will be is a very difficult thing to estimate because we don't

know how much electricity will be produced, among other things, but it will certainly double its penetration in the production of electricity by that time. That is the picture I see.

Mr. YATES. Mr. Evans.

GEOTHERMAL ENERGY DEVELOPMENT

Mr. EVANS. My question was the amount of electricity produced from geothermal sources is currently rather limited and yet you seem optimistic. Is my memory wrong or have there been new discoveries of opportunities in this field?

Mr. FRI. Your memory is correct, although the limitation is quite high. I don't have the exact figure for you, but there is a fairly large amount of recoverable energy from geothermal. It is not like coal or shale, but, larger than the proved reserves of oil and gas and it is located where it is most needed. It is in the West where there is a heavy dependence on oil and gas, where there is not a lot of coal, where the burning of coal particularly in California would compound what is already a serious air pollution problem. While there isn't that much of it in one sense, it is concentrated in the right place and can do us a great deal of good.

Mr. EVANS. There haven't been any new startling discoveries?

Mr. FRI. We think we found—although this will take some more exploration—some possible geothermal sources in the East; Savannah, Jersey City, Norfolk, Baltimore, and Charleston. Those are tentative things. We have announced this possibility but this is still quite tentative. But there are substantial geothermal resources we know about in the West. We have an active program in our 1978 budget to define, and characterize the field a half dozen or a dozen fields of geothermal resources.

ESTIMATED COST OF FUTURE ENERGY INVESTMENT

Mr. YATES. What do you anticipate the cost is likely to be by the 1990's to the Government for all this development?

Mr. FRI. From the time of formation of ERDA to the mid 1980's the total costs have been estimated to be in the neighborhood of $60 billion to $70 billion.

Mr. YATES. How much will industry contribute?

Mr. FRI. The private sector investment in facilities, has been variously estimated in the range of $500 billion to $650 billion, depending on whose particular study you quote.

Mr. YATES. 500——

Mr. FRI. To $650 billion.

Mr. YATES. That is not R. & D.?

Mr. FRI. That is their investment in production facilities. The investment in R. & D. would probably be somewhat less than the Federal Government.

REGIONAL ENERGY PROBLEMS

Mr. YATES. As you see, the United States in the 1990's, with this greater supply of energy, will that supply of energy be available to all parts of the country? Suppose we, in the year 1992, have another winter

such as we had last year. Will we be able to avoid the consequences, avoid what happened last year?

Mr. FRI. If there is still a distributional problem a reoccurrence is likely in the Northeast.

Mr. YATES. Still?

Mr. FRI. The problem right now is in the Northeast since it operates on oil. The gas distribution system is not well developed. We will probably have by 1990 more problems with liquids than with gas. If there is a sudden shortage of liquid precipitated by a cold winter or anything else, it would be difficult to get anything else to the Northeast. That would be where the problem would arise.

Mr. YATES. As I have reviewed the subject, I have wondered as to why we don't contemplate building pipelines from the West to the East. Why don't we find the ways of serving the Northeast by building a pipeline from, say, California? We built Big Inch during the war when we had to do it. California is going to be oversaturated with oil, we are told. We are talking in terms of swapping with Japan oil from Alaska in order to supply the oil to the East. Does ERDA have a function here of doing anything about the transportation of energy or is that some other agency?

Mr. FRI. That problem is predominantly the concern of the Federal Energy Administration, but this consideration is one of the reasons for the Department of Energy. It is just that kind of question that has a propensity to fall between the cracks.

WATER REQUIREMENTS OF ENERGY DEVELOPMENT

Mr. YATES. What about the question of water in 1990? We are going to need water for oil shale, water for coal, and you are going to need a great deal of water for you energy. Do we have enough water in your calculations to take care of everything?

Mr. FRI. We are right now undertaking a study with the Water Resources Council.

Dr. LIVERMAN. Yes; we have a study that has been going on for 2 years with the Water Resources Council and we will be continuing these studies as well as studies with others to address the water question particularly in the West, for example oil shale in Colorado and coal liquefaction and gasification processes. Some reasonable questions exist as to whether or not there will be an adequate water supply if people continue to use it as they use it now. There may have to be alternative methods employed. I don't think it is a limiting factor right now. But we are addressing the issue rather intensively.

Dr. WHITE. In terms of shale, if we want to get 1.2 million barrels per day production, it looks as if it will be a critical problem.

Mr. YATES. Do you have to worry about that problem?

Dr. WHITE. Yes.

Mr. YATES. Do you have to worry about the possibility of meeting that problem?

Dr. WHITE. We have not really been active in that. We recognize this as one of the things that might have to be dealt with.

Mr. YATES. Who would deal with desalinization?

Dr. LIVERMAN. We would be addressing that question too.

Mr. YATES. It would be the Department of Energy.

Dr. LIVERMAN. Clearly, if water is a limiting factor in some areas of our country, I think we consider it ERDA's business to determine what needs to be done at least to explore all the questions. Whether Interior or someone else then ends up in the desalinization business is a question we would have to address when we determine what the limits of the water resources are.

Mr. FRI. You simply cannot talk about the Colorado River without talking about the salinity problem.

UTAH WATER ASSESSMENT

Mr. MCKAY. I am very sensitive to that situation along with my neighbor, the gentleman from the State of Colorado, because we have just been through the new administration's idea to shut down development of existing water projects and CUP. The argument about salinity in the Colorado is part of it. If you take this water and develop it, the problem comes from the fact that you don't dilute it from its original sources but even then the water problem is going to be critical. I have just come from out there. I have been down through those counties. In Carbon and Emery Counties in my district, and Sevier and Sanpete, which are the sources of most of the coal in my State, which would be 20 billion to 70 billion tons of low-sulfur coal, they have no water source. They are trying to tap what they can get out of the mine itself in Carbon County.

In Emery, because of the shale formation there are no wells you can dig. In Sevier County they have no source of water. Their water is spoiled in Beaver, so they have no water source, unless it is transported from the CUP, from what little there is. Kenilworth and two other communities out of there have been out of culinary water for 2 weeks already. You go down in uranium country, Monticello, and they are rationing water. Women are doing dishes out of small pans to save the water for the flowers. They are talking about tapping their sewers to see if they can't use some of that to keep the trees alive. There will be no swimming pools this year. This is in the heart of an energy belt. You get into Duchesne, the area of the CUP, and there is coal, tar sands, oil shale in great volumes. If it ever gets developed, it has to have water.

In my little community we have reservoirs, and if it weren't for them this year because of somebody's planning, 10, 20 years ago, we would be concerned with water right now. In that same area above the reservoirs the wells are dry.

Mr. DUNCAN. I would like to correct you. I think you said it was going to get tough out there. It sounds to me like it is already tough. And what looks like a boondoggle in Plains, Ga., is really the life blood of the area that you and I live in.

If you fellows figure there is going to be a shortage for development of energy, you better get down on Pennsylvania Avenue and tell those people about it.

OBSTACLES IN ENERGY DEVELOPMENT

Mr. MCKAY. My concern with water is no joke out there, and no matter whether you are a miner, whether you are a farmer or what-

ever you are, I have never seen people so up tight over water. The mining problems to get coal out are awesome enough and yet presently they tell me that it takes 2 to 5 years to open a good coal mine. The first 2 years it is just nothing but paperwork.

In your projections for 1985 to 1990 for some of these production levels, it strikes me you are being very optimistic. In the first place it takes up to 5 years to build one plant before you can get electrical generation, so if you start it today you are looking at 1985 before you can get very many coal generation plants and if you add in all those delays for paperwork and environmental impact statements and a dozen other things and you still have to get the technology going, you can't have much of anything except a little knowledge going between now and 1990.

In geothermal it strikes me California has had some success with that for San Francisco and that area. But you go to the Raft River project in southern Idaho and northern Utah and they have all kinds of problems. There are not any consistencies; they can't hold it together.

That is, it is not dependable. They get it and then it drops, and they are having troubles. Utah Power & Light has done some up there and they have been very successful in their bid to tap what obviously seems to be there with hot springs and little geysers and so on.

Another thing that bothers me, because I am in uranium country, is that the President wants to go on with our existing nuclear technologies and yet there will not be a vast resource of uranium as we know it today. We could by the end of the century probably or a little afterward be out of uranium unless we move toward plutonium. In the meantime it is building up.

I don't understand that one. How do we decide we are not going to use plutonium in a breeder reactor, and yet other parts of the world are going to go ahead and do it anyway? There would be a vast source of energy in a breeder reactor because you use up the plutonium that you are building up with existing plants.

I am no technician. You can correct me if I am in error. It seems like we have an awful lot of technology that is right on the brink, just like we have been talking about fusion for how many years now? Twenty at least? We are just not going to get fusion quickly.

We have that same situation with geothermal. We can demonstrate lots of things but we cannot quite get that technology over the top. I think we are in about the same shape with solar, and that same thing with nuclear. We are in that same shape with some of our exotic fuels all the way through. Is that not correct? We are on the brink of lots of things but cannot seem to push them over.

THE ROLE OF ECONOMICS IN ENERGY DEVELOPMENT

Mr. FRI. We are on the brink of a lot of things, many of which have not been pushed over the top. I think what will make them go is whether energy users in this country see a price that makes it look attractive to go to those other sources of energy. That is an absolute prerequisite. That is the problem I think the President has laid on the table, among others, in the energy plan.

We have been successful in the geothermal area in southern California with characterizing some of those resources. They are more consistent resources than in the Utah-Idaho area, however, we do have liquid coming out of a well into some test loops. We are getting ready to build a 50-megawatt demonstration plant which will actually produce electricity.

The Federal Government cannot very well tell a private investor, OK, you have to go and invest your money in several thousand megawatts of geothermal energy unless the private investor figures he is going to make a little profit on that. We can show that the technology works. We can ameliorate the environmental problems. We can do a lot of things but we cannot spend his money.

Mr. McKay. Of course we could probably accelerate to a demonstration situation in conjunction with them rather than us getting into it, just a cooperative effort.

Mr. Fri. Most of these are cost-shared projects.

Mr. McKay. But as we push this price situation up, rather than building the technology to bring it to us, we may be pushing the whole economic structure and inflating the whole thing.

WATER ASSESSMENT RESPONSIBILITY

Mr. Yates. Who is looking into the water question? Should it be Geological Survey?

Dr. Liverman. No, I don't believe this is only a Geological Survey area.

Mr. Yates. The Office of Water Research and Technology is having its budget cut to the bone. It gets a smaller budget every year. As a matter of fact, when they appeared before this subcommittee for its funding they didn't even have a director, so they are not looking into it. They are closing two of their installations. I am trying to find out who is supposed to be making sure that we have enough water.

Dr. Liverman. The Office of Water Research and Technology is only one of many Federal agencies involved with various aspects of the Nation's water supply and water quality. As you perhaps know, it was for this reason that the Water Resources Council was formed in 1965 to bring all major water agencies under one umbrella in order that a coordinated Federal water program could be planned and which would assure that the country has adequate water supplies and quality for all purposes such as municipalities, agriculture, industry, and the like. The Water Resources Council is made up of representatives from eight agencies. A proposal to be a part of ERDA's authorization bill last fall—I believe by Congressman Wirth—would have added ERDA as a member of that Council. But this has not occurred. WRC has an overall water resources planning budget of approximately $13 million in fiscal year 1979 and about $15 million proposed for fiscal year 1978. In addition, as part of a separate memorandum of understanding between ERDA and WRC, ERDA has transferred $1 million to WRC in fiscal year 1976 and a similar amount is planned for fiscal year 1977. This ERDA funding to WRC is directed toward assessing certain critical areas of the country for providing sufficient water for energy development purposes.

Mr. YATES. What are we doing about improving the situation?

Dr. LIVERMAN. I really don't know the answer to that particular question.

Mr. YATES. I guess we better ask the Secretary of the Interior.

Dr. LIVERMAN. He or his representative is the Chairman of the Water Resources Council.

FORECASTS FOR THE 1990'S

Mr. YATES. Let's go back to 1990 or 1992 again. What condition is the United States in at that time? Have we grown substantially? Are we driving small cars? Where are we depositing our nuclear waste?

Mr. FRI. According to our calculations there will be a reasonable growth in GNP, in the neighborhood of 3 to 3½ percent a year, through 1992. There will be some inflationary impact caused by the rise in energy prices. It is not excessively large, a half a point or so as I recall.

INFLATIONARY EFFECTS OF PRESIDENT CARTER'S ENERGY PLAN FOR THE NATION

According to preliminary estimates, the rate of inflation is likely to rise by between one-quarter and one-half of 1 percent during the next 4 years. If the proposed gasoline tax were triggered, the rate of inflation would be likely to rise at the higher (one-half of 1 percent) rate. We can expect that the prices paid by some classes of users for certain fuels would rise relatively rapidly; but that the effective cost to consumers, that is the price net of proposed rebates and tax credits, would fall for many energy-conserving products.

ENERGY TECHNOLOGIES IN THE PERIOD 1985–1990

Your attention is called to the attached table. The impacts shown are measured at the point of final market disposition and adjusted to reflect the value of the fuel form to the consumer. (For example, a homeowner can get much more useful work from a quad of electricity than a quad of oil when it comes to heating his home.) The values are derived from data which will appear in the 1977 edition of the "National Plan" and the range represents a high assessment and a low assessment of the impact a technology could make.

You will note that the only relatively mature technologies by 1985 will be fission reactors and conservation. Coal gasification will probably have become commercial by that time but the other technologies are only just getting up from, or out of, the ground.

Only the first three technologies produce direct substitutes for oil or gas; the degree of their penetration of demand for those fuels is shown qualitatively in the last column. The remaining four cannot be tied to any one fuel.

It must be realized that these values cut across many scenarios and resemble no single scenario. Individual scenarios are necessarily in conflict; that is, a scenario that delivers high nuclear power is not likely to be one that delivers simultaneously, high coal liquefaction and gasification.

POSSIBLE IMPACT OF CERTAIN TECHNOLOGIES

Technology	Range of possible quad impact		Basic fuel replaced	Penetration in 1985, percent
	1985	2000		
Coal liquefaction	0–0.1	0.5–2.5	Oil	Negligible.
Coal gasification (high, low Btu)	.2–1.0	1.4–6.3	Gas	Low.
Oil shale	.2–.5	.9–4.6	Oil	Low.
Geothermal	.1–.4	1.1–5.5	All	Low.
Solar energy	.05–.4	2.2–8.6	All	Significant.
Fission reactors	3.4–4.5	7.9–15.8	All	Major.
Energy conservation	7.1–10.0	13.7–28.2	All	Major.

Coal liquefaction

This technology can produce heavy fuel oils; a synthetic crude oil with generally premium properties; or even high quality materials such as premium gasoline or petrochemical feedstocks to the virtual exclusion of lesser valued byproducts. An aggressive program, such as might be based on the premise of world output of conventional crude oil peaking in the early 1990's, could lead to the higher impact representing the output of perhaps a semicommercial plant in 1985 producing 50,000 barrels per day and more than 12 plants by the year 2000. A business-as-usual program might see the first plant on stream in the early 1990's.

Coal gasification

This technology produces high, medium, and low-Btu gas, each with fundamentally different markets but with the basic need for each stemming from inadequate natural gas supplies. High-Btu gas is directed at producing a product that can be mixed indiscriminately with pipeline gas. The market penetration of this technology is highly dependent on nontechnical issues such as actions of State utility commissions or of the FPC, Federal price controls, or the desire to have an alternate to electrification. Because of the availability of good first generation technology, coal gasification could move ahead very rapidly with 3–5 such plants on stream by 1985, rising to 25–30 plants by 2000 using newer technology.

Low Btu gas is largely directed at the industrial and large commercial markets where the user, for technical or even economic reasons, needs a clean-burning fuel. Because of the low-heat content of low-Btu gas (100–175 Btu per cubic foot) compared with high Btu (1000), this material will generally be used at the same point where it is generated although distribution for distances up to 50 miles might be practical in limited cases. As with high-Btu gas, the penetration of low-Btu gas is controlled largely by nontechnical factors. With the number of plants being built and considered, even an unfavorable outlook could see 5–20 plants by 1985. Given a demonstrated need, and recognizing that these plants will tend to be small, there could be hundreds in operation by 2000.

Medium-Btu gas is a highly specialized product since it requires more capital than low-Btu plants (basically a medium-Btu plant is a high-Btu plant without methanation). The product could become a major petrochemical feedstock and may, since it contains about 500 Btu/cubic foot, be a candidate for some new industrial/commercial distribution grids.

Oil shale

This is the most advanced of the syncrude technologies. Although the economics are not firm, it seems quite clear oil from shale should be $5–$10 per barrel cheaper than oil from coal. Assuming that there is real pressures for additional petroleum and that the socioeconomic problems facing oil shale can be solved, up to four plants could be on-stream by 1985 rising steadily to 20 or more by the year 2000. Even with reasonable supplies of conventional petroleum, steadily rising real prices for that oil could bring forth two semicommercial plants by 1985 with 4–5 commercial plants by 2000.

Geothermal

Current exploitation of this resource is limited to the use of associated steam for generation of electricity. Attainment of the lower impact levels basically requires steady finding and development of new reserves, and evolutionary technical improvements including the use of hot water. Attainment of the upper levels of growth requires rapid solution of all technical and nontechnical problems, a significant input of geopressured reservoir methane, and the construction of a large number of plants by the year 2000.

Solar energy

60–80 percent of the impact shown is produced from solar heating and cooling. Even the low impact numbers for heating and cooling requires a sharp reduction (60–70 percent) in the cost of collectors as well as a steady rise in the price of world oil. The high estimates assume that about one-third of all residential and commercial units use the technology and require broad success in all subtechnologies—solar electric, thermal electric, wind energy, ocean thermal and biomass.

Fission reactors

To achieve the lower level of penetration will require ordering 8–10 plants per year through 1990 (assuming a 10-year design and construction period) as well as operation of the capacity now operating, under construction or on order. Business-as-usual conditions could permit attaining this goal although the effect of the new reprocessing policy has not been measured. The upper level will require ordering 25–30 plants per year and to achieve this will require a greatly improved licensing regimen and a marked reduction in escalation of capital costs of such plants relative to more conventional plant construction. Again, the effect of a changed fuel cycle has not been evaluated.

Energy conservation

The bulk of the energy conservation savings will come from the industrial and residential/commercial sectors (although transportation savings will be critical since they can literally be measured in unneeded oil imports). The incentive for these savings will come from higher energy costs plus proposed tax benefits. The rate of implementation of conservation measures is controlled by the availability of capital. In general, the technology for most of these savings is at hand (industrial recuperators, more insulation in the attic, et cetera) so that the impact will be determined by the cost/availability of conventional fuels and the nature of the subsidy programs offered.

THE FUTURE PRICE OF GASOLINE

Mr. FRI. The employment situation doesn't seem to be seriously affected. In life style terms you do see smaller cars.

Mr. YATES. What are they paying for a gallon of gas?

Mr. FRI. They are probably paying for a gallon of gas something in the neighborhood of 75 cents a gallon, unless the standby gasoline tax—becomes effective. The calculations I have made are based on about a 60-cents-a-gallon price today.

Mr. YATES. How do you get that? Where do you buy a gallon of gas for 60 cents?

Mr. FRI. The Controller says Mclean, Va.

Dr. WHITE. Southern California is selling at that price.

Mr. FRI. Taking that as a jumping off place what we see as the impact of the President's policy is the standby gasoline tax would increase the price to the neighborhood of 75 cents a gallon or about a 25 percent increase. So if you are paying 65 cents you can up it some.

Mr. ARMSTRONG. What assumption is cranked into that as to the price of OPEC oil at that time?

Mr. FRI. The calculation assumes that the impact of deregulation would be about 2 cents. The impact of the wellhead tax would be the balance of the increase. This is all in today's dollars at a landed price of $13.50 per barrel of foreign oil.

Mr. ARMSTRONG. So that if OPEC raised their price to $20 or $25 a barrel your figures would be adjusted accordingly.

Mr. FRI. Yes; there would be some adjustment in those amounts.

Mr. YATES. Ask him the other question. Suppose OPEC cuts its price to about $9 a barrel. What happens to all of his energy?

Mr. FRI. That is exactly so.

Mr. YATES. What do you mean by exactly so?

Mr. FRI. The implication is that if you tie everything to the world price of oil, and the people who monopolize the world price of oil cut it, then all my arguments about price inducing the introduction of technology fall apart. However, the current projections, the CIA report and our own projections, strongly suggest that sometime toward

the end of this century, whether it is in 1985 or 2000 or some other time, the world consumption of oil and the ability of the world to produce oil are going to start going apart. We simply on a worldwide basis won't be able to produce enough oil to meet the world's demand even if there is zero growth in demand per capita. If there is a consequential growth per capita the world gets worse that much faster. So (a) I am not a strong believer in the possibility of a long-term sustainable decrease in the price of oil, but (b) I am a great believer that the national security of this country requires us to pay the price to develop alternative resources because the oil just isn't going to be there 20 years from now.

Mr. McKay. We ought not to be burning it either. It ought to be a feedstock rather than something else that you are recycling.

Mr. Fri. One would like to be able to do that.

SOUTH AFRICAN COAL LIQUEFACTION

Mr. Yates. What processes or technology have you discarded, where you found little promise? Have you discarded any, or are you going ahead on all fronts?

Mr. Fri. We have discarded a few. We terminated the molten salt breeder reactor project a year or two ago. While we certainly haven't discarded coal liquefaction, we are not going to build a big demonstration plant right away because it is a pretty high-priced product.

Mr. Yates. Is that what they are doing in South Africa?

Mr. McDade. What does that mean, pretty high prices?

Mr. Fri. $30, $35 a barrel.

Mr. Yates. Is that what it costs the South Africans?

Dr. White. At least.

That process, of course, has many chemical byproducts. How much you credit for the chemical byproducts is a problem.

Mr. Yates. Did you want to pursue that, Joe?

Mr. McKay. That figure is awfully high from some of the sources I have been talking to.

Dr. White. The $30 to $35 number was the South African figure. Even for some of the best SRC II, the Gulf process; SRC I, you find coal. It may be a little cheaper, but it is still coal.

FUTURE STORAGE OF NUCLEAR WASTE

Mr. Yates. Where is your nuclear waste in 1982?

Mr. Fri. At that time our nuclear waste will be stored probably as spent fuel rods, either underground or in an aboveground facility, and held there for retrievable storage, so that the fuel rods can be brought back out and reprocessed for the energy content.

Mr. Yates. Then they aren't waste. What happens to the stuff you cannot use?

Mr. Fri. By 1985 we expect to have an underground repository for the material that we cannot use.

Mr. Yates. Salt dome?

Mr. Fri. Yes; a salt dome or salt bed, which would be able to accept, for permanent disposal, either the reprocessed waste, that is fission products, or, if necessary, fuel rods themselves.

Mr. McKay. What do you do with all the plutonium you are building up?

Mr. Fri. That depends entirely on the direction the breeder program takes, whether an alternative breeder or advanced converter reactor is brought into play and the need for plutonium to drive that cycle.

PLUTONIUM PROLIFERATION

Mr. McKay. But the administration policy is such you are going to kill it, aren't you?

Mr. Fri. It might be helpful to start with a short discussion of the overall plutonium situation. The problem with the liquid metal fast breeder reactor, from a plutonium standpoint, is that it produces the highest output of plutonium per gigawatt-year, of any cycle I have seen and that the plutonium can be separated from the spent fuel by chemical reprocessing.

There are other ideas such as the thorium breeder cycle which produces perhaps only 20 or 30 percent as much plutonium per gigawatt-year and what is called a denatured cycle. It means that the plutonium cannot be separated, and the weapons material cannot be separated except by isotopic separation, which means you have a very sophisticated plant.

Chemical separation does not require great sophistication in small quantities, so it has more proliferation characteristics. No technology is 100 percent proliferation proof, however.

What we are embarked on now is a look at the alternatives to see which we would like to pursue, balancing economics, energy, and proliferation considerations.

Mr. McDade. Just to pursue that, we had a consortium of universities from the State of Pennsylvania in town last week and discussed the question of plutonium proliferation and restriction of same on the basis of the fact that it would make it a safer world because you could not as readily construct an atomic weapon.

They disagreed with that. When I say "they," I mean the people on the nuclear side of it disagreed radically. They said that India didn't need it, that China didn't need it, that the thought that a small group of radicals could somehow grab some plutonium and come up with an atomic grade weapon is folly, that the stuff itself is so toxic to handle it would require incredible sophistication, and if one were going to convert it into a weapon you would require outlays of hundreds of millions, and if we were assuming the supposition of a group of radicals, or let's say a nation that was acting as a group of radicals, impossible secrecy to take that plutonium and convert it into atomic weapons. What about that?

Mr. Fri. India converted plutonium into a weapon.

Mr. McDade. But not from a breeder reactor.

Mr. Fri. No, not from a breeder reactor. They converted from a heavy water moderated research reactor.

Mr. McDade. This was the point of stopping the Clinch River reactor and of embarking on a national policy that says we are going to get out of this business and we are going to try to persuade our allies to stop this technology; if you continue it you facilitate the growth of lethal weapons easily made around the world. Wasn't that the rationale?

BASIS FOR THE ADMINISTRATION'S DECISION ON BREEDER REACTORS AND REPROCESSING

Mr. FRI. The basis of the President's policy is that the worldwide spread of reprocessing facilities and/or breeder reactors which require reprocessing facilities could lead to an uncontrollable proliferation situation.

Mr. MCDADE. Let me stop you right there. Could the spread of regular conventional nuclear plants do the same thing?

Mr. FRI. Theoretically it could, but let me complete the thought because I think it is important. If there are many reprocessing facilities and many breeder reactors with associated reprocessing facilities around, there are two classic things that you hear about that theoretically can happen. The first is that a terrorist could get his hands on a piece of material and separate the plutonium and make a bomb out of it, drop the material in the local water supply, or whatever. Second, the Nation itself could have a revolution, take over the reprocessing plant and take the plutonium out of it in just a very normal sort of way, very overt.

In my judgment, the more serious consideration is the extent to which you spread reprocessing plants around the world. You not only increase the danger of diversion of plutonium but you also increase the danger that clandestine activity will go undetected. What one would like to be able to do is detect clandestine activity and use sanctions or other means to put a stop to them. Therefore the spread of reprocessing facilities worldwide—has a particularly innocuous effect because it masks the possible of clandestine activity.

I think that point is often lost. If you set out to use commercial nuclear power as the vehicle for a weapons program, it does bring into the country all the capability you need to do a weapons program and masks it with the commercial power activity.

What the President has done in withdrawing from reprocessing and the breeder reactor program is to say we are very concerned; that we are going to look for alternatives; and that we are not going to pursue our program until we have found alternatives.

Now, there is a lot of criticism of the President for the implied assumption that if we stop, everybody else will. That is not what he did. His alternative was to ask everybody to slow down while we sped ahead, and if we are moving ahead rapidly on everything while asking everybody else to look at alternatives there would be zero possibility that other countries would cooperate with us.

In my judgment they would view what we were doing as a simple commercial ploy to let our technology catch up with theirs.

POSSIBILITY OF CLANDESTINE USE OF NUCLEAR MATERIAL

Mr. MCDADE. I understand that. Assuming your worst case though, and that everybody had to have one of these plants, the point was still stressed rather unequivocally that the clandestine feature is virtually nonexistent because of the high technology, the high dollar cost to take that plutonium and convert it. It would just be extraordinary. And the fact that the popular conception—I must say I shared it; I filed a bill to stop the export of the stuff—the popular conception,

however, that a group of 25 highly educated but radical people could sit down and get this material very easily converted to a lethal instrument is absolutely, say they, unequivocally erroneous, because it would require a high degree of technology, enormous sums of money to be able to do it, even under your worst case with every nation having it.

Would you comment on that for me?

Mr. FRI. In my judgment they are wrong, but to explain the reasons they are wrong would take a classified hearing. I am just too uncertain of the classification to proceed much further than that.

Mr. DUNCAN. Would you yield? Did you read Congressman McCormack's article in the Post Sunday?

Mr. FRI. Yes. I glanced at it. I have previously talked to him about that concept.

Mr. DUNCAN. If I did understand it correctly, his point is that you can do all these things that people apprehend from plutonium with uranium, that the first bomb was made out of uranium. It wasn't made out of plutonium, and it was easier to go ahead if somebody is determined to do this sort of thing using uranium or an enriched uranium and that it would be very easy to make this plutonium in such massive segments that you just couldn't put it in your hip pocket and walk away. Can you comment on his article? You just scanned it?

Mr. FRI. Yes.

Highly enriched uranium is as effective in principle——

Mr. DUNCAN. And easier, isn't it?

Mr. FRI. Not necessarily. Highly enriched uranium is more difficult to prepare. Plutonium toxicity is not an acute poison like arsenic where if you take a little bit you drop over dead. Over a long time of exposure inside the body it can produce cancer by emitting alpha particles. Unless it is in the body it is very easy to shield against alpha particles. A sheet of paper or a thick rubber glove will shield you well from alpha particles. We deal with plutonium in our weapons facilities by reaching in with heavy rubber gloves to handle material by direct contact, so it is not quite the bugaboo that is cracked up to be. It is dangerous material, but it can be handled relatively straightforwardly.

Mr. DUNCAN. But that isn't true with uranium?

Mr. FRI. Highly enriched uranium.

Dr. LIVERMAN. Both uranium and plutonium do emit gamma radiation in addition to the alphas, however, handling uranium metal, in general, does not constitute an external radiation exposure problem because of the relatively weak energy of the gamma emissions. Like plutonium, the real concern with uranium is the possibility of inhalation and internal deposition for which greater safety precautions must be taken. It should be noted that handling of plutonium on a continuous basis does require limited shielding protection of extremities against any gamma or neutron radiation, however, this is not considered a serious external radiation problem and is dealt with quite easily.

Mr. FRI. But you can still handle it?

Mr. YATES. No problem.

Mr. FRI. Neither is that difficult. Yes, you can make a bomb from highly enriched uranium. But to do that you have to have an enrichment plant to produce the material.

Mr. DUNCAN. So it cancels out, does it? We get just as much using these light water reactors in enriched uranium plants?

Mr. FRI. Uranium light water reactors use low enrichment uranium and you cannot make a bomb out of it. However there are other fuel cycles that use uranium as the fissile material, like uranium-233, and that can also be converted into a weapon. There are also ideas that use what is called a denatured fuel. You mix uranium-233 with uranium-238 and you cannot get it apart again chemically. It would have to have more difficult for a terrorist to take it apart. He would have to have an enrichment plant. Enrichment plants are nontrivial things to build.

Mr. YATES. Can you answer Mr. McDade's question without using classified material? If not, I think Mr. McDade has suggested that Dr. Fri be here at more of our hearings. Would you be interested in getting it classified?

Mr. DUNCAN. I sure would.

Mr. YATES. How about 10 o'clock on Wednesday? We will be here Wednesday morning at a closed meeting to get classified material.

Mr. FRI. I may be able to do it in an unclassified way, but there are things that are classified and just off the top of my head——

Mr. YATES. You can prepare yourself for a meeting on Wednesday morning. If you want it to be open we can have it open, or if you want it to be closed we can.

Mr. MCDADE. I would appreciate it. I think it is an important issue for us to face. The ability of the community to try to get a scientific consensus is very important to us, and we would like you to know about it.

Mr. FRI. Sure. It is an important question.

Mr. YATES. Ten o'clock, if that is all right with you.

We have 7 minutes remaining before we adjourn until 1 o'clock.

THE ROLE OF CONSERVATION IN THE FUTURE

Mr. YATES. We haven't talked about conservation. I would like to have an overview on conservation, what are we doing; how does it look; where are we going? In 1992 will all our buildings be insulated?

Mr. FRI. I think we will see a great deal of insulation. I think by that time we will see the introduction of a wide variety of individual products that are more inherently energy conserving.

Mr. YATES. You are talking about electrical accessories?

Mr. FRI. Light bulbs that use less energy per unit light, integrated energy systems in communities, the use of fuel cells which are more efficient using either natural gas or gasified coal, integrated appliances where the heat from one appliance is used by another and so forth. A whole variety of things like that will come into being.

Most importantly by 1985 to 1990 we should see the introduction of the new heat engines using either the Stirling cycle or the turbine, both of which can be more efficient while meeting environmental standards.

CONSERVATION AT THE IBM BUILDING IN CHICAGO

Mr. YATES. Are you aware of the operation of the IBM building in Chicago?

Mr. FRI. I have read about it, yes.

Mr. YATES. Can you explain that for the committee?

Mr. FRI. I am not that familiar with it.

Mr. YATES. As I understand the operation of the IBM Building, it takes the heat from its light and distributes it throughout the building.

I see Dr. Gouse. Are you familiar with it, Dr. Gouse?

Dr. GOUSE. I believe that the Westinghouse Building in Pittsburgh utilizes that type of system.

Mr. YATES. Having said that tell us what it is.

Dr. GOUSE. You run air ducts with your lighting fixtures. You can pick up the heat from the lighting fixtures and use it in other parts of the building for other purposes.

Mr. YATES. They rarely use their boilers.

Dr. GOUSE. That is correct.

Mr. YATES. They also use the heat from human bodies too.

Dr. GOUSE. That is right.

Mr. YATES. They use computers to distribute that.

Dr. GOUSE. Yes; such techniques can be used. It is a matter of how much capital you want to put into the building and trade it against fuel charges over the life of the building.

Mr. YATES. Does it work?

Dr. GOUSE. Sure it works.

Mr. YATES. Does it work on a cost basis?

Dr. GOUSE. I would say it is going to work on a cost basis.

Mr. MCKAY. If you raise the price high enough.

Dr. GOUSE. No; it will go high enough by itself.

Dr. WHITE. You are using electric heat to heat that building, and that is not a cheap way to do it.

Mr. DUNCAN. You are using electricity to light it so you might as well use the heat.

Mr. YATES. But you are not using electricity to heat the building. You are using it to light the building.

Dr. GOUSE. You are using the waste heat from lighting.

Mr. FRI. As I recall, the Massey building in Fairfax County, Va., where the Fairfax County Government sits, has the same concept.

Mr. YATES. Why doesn't it make sense to do that more and more?

Mr. FRI. It does. We have to build it in to the building from the very outset.

Mr. YATES. How much more do you have to pay for that kind of a system over an ordinary heating unit? Do you have any idea? It would be interesting to find out from IBM how much more it costs.

Mr. FRI. Those are gamey statistics, because if you build some of these energy conservation ideas from the ground up it might cost less than the normal construction when you build from the ground up.

HEAT SYSTEM IN CHICAGO IBM BUILDING

The heat recovery system in the Chicago IBM building is based on recovering heat from a large computer installation. The computers occupy three floors of the building and the recovery system satisfies the building's heat load. Design calculations predict annual energy usage of 117,000 Btu per square foot per year—all electric.

Savings of approximately 30 percent were achieved as compared to other Chicago office buildings based on 3 months data collection during the heating season. This data was projected to account for $204,000 per year in energy savings predicted on current Chicago electric energy costs.

The incremental costs associated with this effort are $500,000.

THE LITEK LIGHT BULB

Mr. YATES. Let's come back at 1 o'clock.

Mr. DUNCAN. One question before they leave. Last year or the year before you fellows were talking about the fluorescent fixtures that you were going to build into an incandescent fixture. Is that one that you dropped?

Dr. MANNELLA. We are continuing work on that, and we are seeing some progress in the development to try to package all the miniature electronic parts into the base and have it turn out to be a reliable unit.

Mr. DUNCAN. I thought you had it whipped a year or two ago?

Dr. MANNELLA. No.

Mr. YATES. Your predecessor had his whipped.

Dr. MANNELLA. I think we have a way to go before it is a commercial product.

Mr. YATES. Let's come back at 1 o'clock.

DISCONTINUED RESEARCH

I had asked you about research that you had discontinued and I think you mentioned one item that you were no longer looking into, the question of the molten salt.

Dr. WHITE. The liquid metal turbine cycle advanced power system has been dropped. COED has been dropped some time ago. The CO_2 acceptor pilot plant is winding down and there are a number of others which are on the ragged edges. Those are the ones that come to mind.

ENERGY DEVELOPMENT SUGGESTIONS

Mr. YATES. What do you do with respect to the enormous number of suggestions that are made to you, or requests for support? How do you go about checking to see whether something is worth investigating? What is the process?

Dr. WHITE. Typically we use the peer review process. Many of these come in from the small inventor-type or college professor who wants funding. We have a system of turning those out to experts within the Federal establishment and those outside and have a list of consultants who will help us do this.

Mr. YATES. Do you have any way of totaling the number of energy suggestions you have had with respect to where you ought to go in the field or research?

Dr. WHITE. We have those statistics. I can't quote them. Hundreds of them come in.

Mr. FRI. Just in one program alone, which are the items we send to NBS for evaluation, we had received 4,491 submissions.

Mr. YATES. Very good.

You have been in business a little over 2 years. In that time do you think you have made any impact on our energy progress?

Mr. FRI. I don't think anything ERDA has done has saved actual energy in this 2-year period but I think we have begun to put in place the new ideas that will start to have significant impact in the early 1980's and a very major impact in the decade following.

Mr. YATES. You have pretty well laid out the channels you hope to develop by your testimony this morning.

Mr. FRI. Yes.

IMPACT OF THE PRESIDENT'S BREEDER REACTOR DECISION

Mr. YATES. Had you fully answered the question as to the impact of President Carter's statement on the breeder reactors? You started to, as to what you envision that would do in terms of energy progress.

Mr. FRI. I think the issue with respect to the breeder boils down to two things from an energy supply standpoint: First, the availability of uranium ore in the country, and second, assumptions about the rate of growth of electric generating capacity after the year 2000. If that rate of growth is relatively low and if there is a reasonable amount of uranium ore around, then there is clearly adequate time to examine alternative reactor concepts and proceed with a new one.

If all of our assumptions fail on the wrong side, then the nuclear industry could conceivably have some kind of interregnum when we run out of uranium and are unable to put in place the breeder reactor. To some degree there is a calculated risk, but the calculation is, I think, a reasonable one in light of the proliferation problem.

FUSION ENERGY DEVELOPMENT

Mr. YATES. You didn't mention fusion at all this morning. Is that so far into the distant future that it doesn't deserve our present consideration?

Mr. FRI. That is essentially a next-century item. There may be other ways of accessing fusion technology for earlier application. We have never systematically studied these alternate concepts, but we have just started a major study of that kind of question a couple of months ago.

For example, fusion energy could be used for breeding with a much less advanced fusion technology than would be needed to produce fusion power.

URANIUM SUPPLY

Mr. YATES. In view of the President's decision to curtail development of the breeder, what effect will this have on our supply of uranium, say over the next 25 years?

Mr. FRI. Our supply of uranium is variously estimated to be between 1.8 million and 3.7 million tons domestically. The lower figure would support about 300 light water reactors for their 30-year life; the higher figure, about 600 for their 30-year life. This estimate needs to be firmed up. We have the national uranium resource evaluation program which is being reoriented for the express purpose of verifying our estimates.

Mr. YATES. If the breeder is postponed indefinitely, must the energy which it would create be supplied by alternate sources?

ADVANCED CONVERTOR REACTORS

Mr. FRI. If you never had a breeder or other advanced reactor, you would have to have an alternate source of supply. But there are other

concepts such as advanced converter reactors which are more efficient burners of uranium than the light water reactor. There are a variety of concepts that could extend the usefulness of our uranium resource.

NUCLEAR WASTE STORAGE

Mr. YATES. Do you anticipate that fuel discharged from the reactors without reprocessing will be stored commercially or stored by the Government?

Mr. FRI. In the end it will be stored by the Government. There may be an interim period of commercial storage.

Mr. YATES. You see it in salt formations at the present time.

Mr. FRI. That is the most likely formation but we are investigating a variety of other formations as well.

Mr. YATES. What are you going to encase it in before you put it in the salt dome?

Mr. FRI. The reprocessed materials are encased, first of all, in a steel case.

Mr. YATES. What happened to the ceramic?

Mr. FRI. Reprocessed material is vitrified in the ceramic, the ceramic is melted into a steel cask which is capped and then the cask is the basic storage container.

Mr. SPURGEON. It would also be disposed of in a stainless steel canister around which a packaging material would be placed to give it a nonleachable character in its long-term storage mode.

Mr. YATES. What do you put over the steel cask?

Mr. SPURGEON. That is the outer material.

Mr. YATES. I am sorry. I thought you encased it in something.

Mr. SPURGEON. No.

PROPOSED DEPARTMENT OF ENERGY

Mr. YATES. Are you currently working with FEA to consolidate your activities in view of the proposal of the President?

Mr. FRI. Yes; we are. I met with Jack O'Leary at an early time and we set up a program to begin doing that. We have a memorandum of understanding with FEA in process. Mr. O'Leary and I have appointed someone from ERDA to bring all those programs together and that is working more smoothly now.

Mr. YATES. How much of your current data-gathering activity do you expect to transfer to the Energy Information Administration? What types of data systems do you expect to keep with either energy R. & D. or the conservation activity?

Mr. FRI. We have two principal kinds of data-gathering activities. One is data on energy resources. Probably all or part of the national uranium evaluation program would be lodged there. We do have a data activity in our planning function which would also be placed in the Information Administration.

Mr. YATES. Are your demonstrations and commercialization separated from the R. & D. activities under the Assistant Secretary for Resource Application?

Mr. FRI. The specific division of labor between that assistant secretary and the Assistant Secretary for Technology has not yet been worked out, but the basic idea is to have commercial applications in the Assistant Secretary for Resource Application. I think it is important that the R. & D. people be maintained under the Assistant Secretary for Technology so that R. & D. efforts are not diluted.

ENERGY INVENTION EVALUATION PROGRAM

Mr. YATES. You have a program for evaluating energy inventions that you worked out with the Bureau of Standards. How many inventions are you funding now?

Mr. FRI. How many are we funding?

Mr. YATES. You said that you had 4,000 inquiries about funding.

Mr. FRI. We had 4,491 inquiries. We have actually evaluated about 2,000 of these through the NBS complete process, of which 27 were recommended to us by the NBS for action. Of those, 12 have been accepted by ERDA for consideration of assistance, 11 are still being evaluated, and 4 have been rejected. Funding in this case may mean either funding as a part of the program or some assistance in the business management aspect of the invention so that the individual can receive private financing.

Mr. EVANS. I understand you only have directly funded one in terms of a grant of money.

Mr. FRI. That is correct, one has received funding, another received marketing assistance, and several inventions are in the procurement process in anticipation of funding.

Mr. EVANS. Could you specify which ones and for how much?

Mr. FRI. I can give you the titles but I will have to submit the dollar figures for the record, if I may. An invention having to do with power conversion of energy fluctuations has been funded for $40,000. Three we arranged business management assistance for the individual. No further R. & D. was required.

Mr. EVANS. Three you arranged for management assistance, one you funded for $40,000?

THE INVENTION EVALUATION PROCESS

Would you care to comment on this? It appears as though the National Bureau of Standards is processing them. You mentioned the 4,000 some odd that come in, but that is the National Bureau of Standards, not you. Isn't that correct?

Mr. FRI. That is right.

Mr. EVANS. With certification that they are basically physically possible.

Do they send them with a recommendation that you consider them for funding?

Mr. FRI. No. They send it with the technical judgment that it is a feasible idea. It is up to us to decide on the funding. I think it is important in this area to understand what we do. Many of these inventions are proposed without the benefit of a working model and without test data. Therefore, is is very difficult for some of these inventions to

compete either with our programs or in the private sector because they are not as fully developed as an invention that might be sponsored by a company.

There is no working model or test data. Our first job is to bring the status of the invention up to a point where there is a working model and sufficient test data so that it can be evaluated by our program on an equal footing with other proposals.

We set aside $1.6 million in 1978 just to bring the inventions that need further testing or working model development up to an acceptable level. Then we help the inventor figure out whether it is the kind of idea that ERDA ought to be funding or whether it is the kind another agency or the private sector would be more likely to fund. We put him in touch with the applicable ERDA office, other Government agencies or private sector. We let him compete with other proposals for ultimate comment.

SUCCESS OF ENERGY INVENTION EVALUATION PROGRAM

Mr. EVANS. Would you care to comment on the procedure so far? This was something that arose out of the act of 1975 or 1974. It would appear to the untutored eye that while the National Bureau of Standards is able to pass on a great number of these, you seem to have difficulty in passing on the few they suggest for examination.

Mr. FRI. We have had some difficulty. We didn't get our first evaluations back from the Bureau of Standards until something under 1 year ago. Until we had three or four passed back we weren't sure what it was we were getting.

Mr. EVANS. When you say pass back, what does that mean?

Mr. FRI. An invention that has gone completely through the evaluation process at NBS and furnished to us with their seal of approval. We have had to work a process to handle those inventions. At first we just referred them to the program offices, asking if they would like to fund them.

The program divisions would say that it is an interesting idea but without test data there is no way to compare it to the other proposals we have had. We realized that what we had to do was to spend enough money to bring these inventions to a state of development so that they could compete on a fair basis with other proposals, either to us or to the private sector. It was only a couple of months ago that we really got our arms around this procedure and made the money available for that type of evaluation.

SOURCE OF FUNDING FOR INVENTION PROGRAM

Mr. EVANS. In your budget do you have a line item for these kinds of things?

Mr. FRI. No, we do not.

Mr. EVANS. Where have you gotten the funds and how much did you set aside for this? Do you have a discretionary fund?

Mr. FRI. We view this as a part of everybody's program and we will have to ask the Controller to explain the mechanism. We identified a total of $1.6 million to support the invention program so that the inventions would be developed to the point where they can compete

fairly with other proposals. Then it is up to the invention to stand on its own merit.

Mr. EVANS. How did you arrive at the figure $1.6 million?

Mr. FRI. Pretty much arbitrarily. We believe it will take an average of a little over $25,000 to bring an invention to the point where it can be fairly evaluated and we might be dealing with 60 or so of these items a year. We multiplied it out and said about $1.6 million ought to cover it. It was not terribly scientific.

Mr. EVANS. Does it give you a manpower or organizational chart problem?

Mr. FRI. It had given us an organization chart problem, but we recently located the program under our Assistant Administrator for Institutions Relations, in the Industry Relations Office that handles small business. They run the program and see that the proposal is brought up to snuff and help the inventor decide whether he wants to compete for private or ERDA money.

Mr. EVANS. You have had about 9 months' experience in this now since you received the input?

Mr. FRI. Something less than 1 year of really dealing with these inventions.

Mr. EVANS. Thank you, Mr. Chairman.

REVISIONS TO INVENTIONS PROGRAM

Mr. YATES. What about Mr. Csonka and his new carburetor?

Mr. FRI. His carburetor came back from NBS with a favorable report, and it is presently under evaluation.

Mr. YATES. The newspaper has kind of a sad story on it.

His frustrations were such that they prompted the following candid self-criticism from one Government official involved: "The Government is not literally set up to deal directly with individuals as we deal with Boeing or Douglas or someone with a Washington office," said Richard K. Sutz, Director of the Energy Research and Development Administration inventory program. "A guy from Boeing can come in twice a day. They know the words to use. It is a matter of grantsmanship. ERDA is not set up to deal with small people," he said.

I guess that is kind of a tragic fact of life; isn't it?

Mr. FRI. Mr. Sutz is basically correct. About the time this article came out, and as a result of an encounter with Senator Hatfield I dug into this program and realized the problems we were running into. We were sending these inventions around for evaluation without their having been developed to the point where it could compete with a new idea from Boeing. If Boeing comes in with a new idea, they have all the test data and working model. That is the reason we decided to set aside some money to help the inventor get his proposal to a level essentially comparable to what Boeing might submit, and then let it stand on is own two feet.

Mr. YATES. Are you doing that now?

Mr. FRI. We are now doing that.

Mr. YATES. How long does it take you to evaluate an idea?

Mr. FRI. It takes about 5 to 7 months to work its way through the NBS process. Then, depending on what we get back, it could take several months to complete its evaluation at ERDA. It would depend on whether the invention needed further development or whether it could be packaged and sent into the program office right away.

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REGENERATIVE BRAKING SYSTEM

Mr. YATES. Mr. Duncan was telling me about the man who visited his office last week apparently unable to obtain financing from ERDA. He had an idea of putting accumulators at each wheel of the car and taking the transmission out of the car and as the car draws to a halt at a stoplight, for example, the energy buildup in the accumulator and the engine stops and as a result isn't drawing any gasoline. The accumulators start the car when the light changes and the engine catches on and it moves on.

He said the savings on this car went from about 19 miles a gallon to about 55 as a result of that. What happened to that I don't know.

Mr. FRI. It sounds like the so-called regenerative braking system which we are now doing some work on.

Mr. YATES. We are told the reason ERDA did not see anything attractive about it is because ERDA is committed to a flywheel principle as opposed to this kind of principle. I didn't know you were committed to anything.

Mr. GREER. We are working on both the flywheel and regenerative braking.

Mr. YATES. Is that what you would call his accumulator?

Mr. GREER. That is my guess. I would need to know more about it.

Mr. YATES. We will have Mr. Duncan tell you about it when he comes in. It sounds like a very interesting possibility.

ERDA PATENT POLICY

What is your reaction to mandatory licensing on patents? Is the Government's right being protected?

Mr. FRI. Yes. I think by and large our patent policy is working out well. We are proceeding somewhat cautiously, but I think there has to be the ability for a company, particularly one who has put a great deal of its own money into the background package for a device that requires some governmental assistance at the demonstration stage, to either retain the patent rights for a period of time or get an exclusive license from us to develop the technology for a period of time so they can make some return on their money.

We have had some protracted negotations over patent rights.

Mr. YATES. Where do you come out? What kinds of arrangements have you made with companies?

Dr. WHITE. We have a number of sharing arrangements where the patents will actually be owned by the contractor with an agreement to split royalties with the Government, in relation to the funding, just like it would be a private joint venture.

Mr. FRI. Mr. Rawicz, who is our Deputy General Counsel is here.

Mr. YATES. What do you think about licensing patents under this kind of arrangement, for example, to other companies working in the same field?

Mr. RAWICZ. There are two different types of situations involving mandatory licensing. One refers to the requirement to license all energy patents regardless of who owns them. We have that kind of authority in the Atomic Energy Act where we can require anybody who owns a nuclear-related patent to license it. That is also available in

the Clean Air Act. Congress asked us to study this question for all energy patents and we are doing that now. We are in the process of studying the impact of mandatory patent licensing on the energy scene, and we would hope within about 3 or 4 months to report to the Congress specifically on mandatory licensing.

The second item on licensing deals with what we call background patent rights. That is the rights that the developer would have that are necessary in order to use the technology developed under our program. There is no statutory coverage on this but our general policy is to put a provision in the contract to require the owner of such patents to license other manufacturers under conditions that are reasonable.

In some cases we have demanded that he reduce his royalty by a percentage which would reflect our investment. In other cases, depending on what type of incentives are necessary, we have provisions that would delay the requirement for him to license his patents for a certain period of time and then if he hasn't commercialized the technology at that point, would require him to license at a reasonable rate.

STRIP MINING POLLUTANTS

Mr. YATES. Why is ERDA funding work on pollutants from strip mining?

Dr. LIVERMAN. We felt it is a part of our responsibility to address this question. When we have appeared before the House Science and Technology Committee in the last 2 years in authorization hearings, they pointed out the need for us to address this question. The programs we have are fully coordinated with the Bureau of Mines in the Department of Interior, USDA and so on. As a matter of fact, our Argonne National Laboratory, which has been our lead laboratory, has been a focal point. For these efforts we had a meeting there about 6 weeks ago of 14 Government agencies. It was a conference directed toward better coordination of all of our efforts. Argonne National Lab has been working with the States—and I would be glad to send you a brochure that shows the nature of the interactions with the State and local people—and with the industry and coal-mining industries—to try to make sense out of the total program that is being carried out by the Government, by the industry, and elsewhere, to look for better means of restoring the stripped-mined lands, and to looking at better control measures for deep mining, acid drainage, and other things.

Our program, while small in this area, is taking an integrated look at the nature of the question and how the issues can be dealt with in a meaningful way in an appropriate timeframe.

		REGION	PARTICIPANTS				DECREASE IN WATER QUANTITY AND QUALITY		LAND RECLAMATION AFTER MINING			HEALTH	TECHNOLOGY	SOCIO-ECONOMICS
			COAL COMPANY	ACADEMIC INSTITUTION	FEDERAL AGENCY	STATE OR REGIONAL OR OTHER LABS	HYDROLOGIC	AQUATIC ECOSYSTEMS	GEOPHYSICAL GEOCHEMICAL	TERRESTRIAL ECOSYSTEMS	EDAPHIC	ATMOSPHERIC	RECLAMATION TECHNOLOGY DEVELOPMENT	LAND USE MANAGEMENT
PROGRAM PLAN DEVELOPMENT	PROBLEM IDENTIFICATION	8 REGIONS												
	CURRENT RESEARCH IDENTIFICATION	8 REGIONS												
	5-10 YEAR PLAN	8 REGIONS		START 3 QTR 1976										
	TECHNOLOGY TRANSFER	8 REGIONS		START 1976										
FIELD AND LABORATORY RESEARCH	BIG HORN MINE	NORTHERN GREAT PLAINS	PETER KIEWIT & SONS	SHERIDAN COMMUNITY COLLEGE	INT. DU. FISH & WILDLIFE	WYO. STATE FISH & GAME DEPARTMENT								
	INDIAN HEAD MINE	NORTHERN GREAT PLAINS	NORTH AMERICAN	ARIZONA STATE UNIVERSITY	AG. RESEARCH SERVICE (SEAM)	OLD WEST REGIONAL COMMISSION								
	JIM BRIDGER MINE	MOUNTAIN	JIM BRIDGER	U. OF WYO. DEPT. OF PLANT SCIENCE								FUTURE PROGRAM		
	BLACK MESA MINE	SOUTHWEST	PEABODY	U. OF ARIZ. NAVAJO COMM COLLEGE										
	SAN JUAN AND NAVAJO MINES	SOUTHWEST	WEST. COAL AND UTAH INTERNAT'L	N. MEX. STATE BRIG. YOUNG UNIVERSITY	U. S. FOREST SERVICE (SEAM)									
	GOOSE LAKE PRAIRIE STATE PARK	CENTRAL	ABANDONED			I.I.E.Q.; ILL. DEPT. OF CONSERVATION								
	MACOUPIN COUNTY REFUSE AREA	CENTRAL	ABANDONED			I.I.E.Q.; ABAN. MINE LANDS RECL. COUN.								
	MIDWESTERN	CENTRAL	3 CO. CONSORTIUM	TO BE DECIDED										
	EASTERN	EASTERN		OHIO STATE UNIVERSITY					PRELIMINARY PLANNING PHASE					
MODEL DEVELOPMENT AND SYSTEMS ASSESSMENTS	BIG HORN	NORTHERN GREAT PLAINS												
	MACOUPIN COUNTY	CENTRAL												
	BLACK MESA	SOUTHWEST	PEABODY	UNIVERSITY OF ARIZONA										
DATA SYSTEM DEVELOPMENT	GEOCODED ENERGY & ENVIRONMENTAL SYSTEMS	ALL			EPA SEAM	LLL ORNL								
	CURRENT RESEARCH INFORMATION STORAGE & RETRIEVAL SYSTEM	ALL				OWRC 4 CORNERS COMM.								
	BIBLIOGRAPHIC INFORMATION RETRIEVAL SYSTEM	ALL				ORNL								

Land Reclamation Program Elements and Cooperating Organizations.

Mr. YATES. There is a question in my mind as to whether or not you are spending money to do the same things the Bureau of Mines is doing.

Dr. LIVERMAN. My belief is that we are not, because they are fully coordinated with us.

Mr. REGULA. I don't follow why your two agencies should be doing it. Even if you coordinate, there is bound to be a waste of effort. Why not let one of the agencies do the job? What is the logic of having two involved?

Dr. LIVERMAN. The logic that applies here is a different logic than applies in the technology area. There are 20 Federal agencies in Washington, D.C., working in the environmental area. The way we are proceeding to address precisely the concern you have, namely, no unnecessary duplication, no unnecessary overlap, is to get those 20 agencies around the table to discuss all our program and to inventory all of the currently supported research and development. We are working on this problem in the health area, the environmental area, and the characterization and monitoring area with the representatives of the agencies. We are going over in detail what is being done. We then try to insure that, in part, we are not duplicating our efforts but also that there are no holes in the R. & D. that should be filled by an agency.

Because there are so many agencies in town, it is not a very clean-cut question as to who should be doing what.

Mr. REGULA. From the standpoint of an agency, wouldn't this be better if it were in one agency rather than 20?

Dr. LIVERMAN. You have regulatory agencies like EPA who needs information so one cannot prevent it from getting into it. On the other hand ERDA has a responsibility to insure that its technologies are there safe and clean back in the process part of the fuel cycle. We are not actively involved in a major way now in coal mining yet the ability for Phil White and his people to develop a gasification plant or carry out an oil shale program in some area of the country depends upon the availability of that coal or shale in a time frame that meets our goals. I guess I question whether we can rely almost totally, but not completely, upon what the priorities might be in another agency's program.

Mr. FRI. Establishment of priorities is a key point. For example, EPA has a heavy metals program and they are studying certain metals for their environmental effect. They could say that was of a low priority. We come along and we are developing a coal technology which has some heavy metals problems; but the particular metal that may be our number one priority may be low in EPA's ranking. Then we talk to EPA so their needs and our needs are met in a timely way. Very often it is possible to do that. Dr. Liverman has a fantastic system. We have identified some 500 requirements for environmental needs in technologies.

The Federal Government has over 3,500 projects presumably supporting those requirements. Dr. Liverman has a team of people sitting down and examining these projects to mesh them together with the requirements to make sure there isn't any duplication.

Dr. LIVERMAN. As an example, the OMB was concerned about this problem in the health area. Since ERDA and EPA were the two principal agencies, they got us, with descriptions of our health projects, down around a table. They did the analysis and out of over 600 projects they found there were perhaps 6 which seemed to overlap. It turned out that when they investigated that there was, in fact, one in which there was an overlap and both EPA and ERDA were both supporting that project in the same institution. A little discussion showed there was no duplication. So I think we are working on this problem. Administratively, it might be cleaner to put it all in one agency, but because of the different responsibilities it is almost impossible.

OBLIGATION OF ERDA FUNDS

Mr. YATES. Deferral No. D77–55 proposes the deferral of $80 million of unobligated balances carried forward from prior years. Are any of those funds under this subcommittee's jurisdiction? The answer is no?

Mr. FRI. The answer is no. That is correct.

Mr. YATES. The committee is concerned with your continuing slow rate of obligation of funds. Despite some improvement last year you carried over into 1977 over $122 million in operating expense funds and this year, through the first 5 months, ERDA has obligated only $110 million, only 20 percent of the available funds. Why the lag there, Mr. Greer?

Mr. GREER. The biggest single reason is the long time needed to process some of our contracts through the system. We currently have some 8 major contracts that are in the final stages of negotiation.

Mr. YATES. How much money is involved in them?

Mr. GREER. About $80 million in those eight contracts, and that will cover substantially the fossil obligation. The major lag has been getting the procurements through the system and out.

Mr. YATES. That was the complaint last year too, wasn't it?

Mr. GREER. Yes.

Mr. YATES. As I recall, and I don't have the transcript at hand, there was a tremendous lag in putting contracts through. Is it the very nature of the contracting process that requires such a time lag?

Mr. GREER. That is correct. These major solicitations involves questions of patent, questions of policy, questions of costs and participation, and wanting to give everybody a fair shake at the competition. As a result we see leadtimes much longer than might otherwise be expected.

THE ERDA PROCUREMENT PROCESS

Mr. MCKAY. Speaking about contracting, I think last year the committee discussed some of the problems of getting to the point where you go to lease and it was taking, I think, as many as 21 stops to get through to the letting of a grant or so on. Are we getting that together? That is maybe half of our leadtime, isn't it, or more?

Mr. FRI. It breaks down into two pieces: One, the time it takes Dr. White to get a procurement request worked up and to the procurement people; then there is the time to actually do the procurement. We now have a system where we are able to track the initiation of the

procurement request and the time it takes to do it. This year we are pretty current on initiations. The procurement aspect is still not everything we would like.

Mr. McKay. I think one of the things that bothers us, you got together with FEA and AEC and you are still collating the requirements.

Instead of eliminating work you just added them and you wound up with three times the paperwork before you could get that thing through. Do you think you have it done now?

Dr. White. My personel feeling is that it is still a very severe problem with us. One of the things we have to recognize is that we previously did not have the type of contract that we are now trying to get, where we are cost-sharing the project going into the commercial market. This is turning out to be a good deal tougher to negotiate and it can be exemplified by the pipeline gas proposal where contractors were selected last July and yet neither of those is yet signed. It has been an interminable process to go through all these points. Part of it is a learning process of dealing between the Federal Government and industry in this type of contract.

Mr. Fri. It has taken a lot longer time just to negotiate the patent rights, for example.

Mr. McKay. But if the Government in fact is building up the greater curriculum to which we have to be schooled before we can apply, we are maybe fulfilling our own prophesy about leadtime. We need to come down to what is essential and what is nonessential and how many desks and egos have to be crossed before we get to where we need to go aside from the need for the fact when those same facts have to cross a half dozen different desks before somebody says, "That is my jurisdiction" versus your jurisdiction.

We had some very definite feeling you had gone through the space program and built up certain criteria because when you send somebody to the moon you have to be sure nobody gets killed. Then you get the atomic development and they have a set of criteria. Then, when we bring these things together, somehow they mesh. When they come to fossil fuels, we get the distinct impression rather than that all we did was add them to fossil fuel and to space and atomic and we had to go through every one of those things before you could get it out. Am I wrong?

Dr. White. I think there is a certain amount of validity in what you said.

Mr. McKay. It is no wonder the Government is in disrepute where we can't get down to where we need to be rather than where everybody wants to be.

Mr. Murtha. Are you talking about the proposals for the grants?

Mr. McKay. Contracting was part of it but you can't get to a contract until you sign off on all these recollections; isn't that true?

Mr. Fri. That is right. Certainly in the early days of the agency all the requirements from the predecessor agencies got thrown into a pot; but the other thing happened that Dr. White mentioned. We started writing contracts that none of the predecessor agencies had ever written, and we didn't know how to do it. Over the course of the past year we brought in a new director of procurement and we have been doing

things such as standardizing the manual, standardizing the procedures, set targets for procurement leadtime, and then within that target go back and see if we can't shave off time. We had some successes but it is still a very long process.

Mr. McKay. As a result of that recoordination, determination and study, how many of those checkoff points did you get rid of?

Mr. Fri. I can't tell you. But I can supply it for the record.

Mr. McKay. We would be interested to know.

[The information follows:]

IMPROVEMENTS IN ERDA PROCUREMENT PROCESS

For the last 2 years, ERDA has been improving the quality of its procurement and speeding up the process. This is a continuing effort.

For instance, new time standards for the steps from identification of a requirement to award of contract have reduced the time for a procurement action from that being experienced 1 year ago.

A centralized system for control and tracking of unsolicited proposals has been installed to assure appropriate and timely action.

A standard procurement request form has been adopted to expedite the preparation of the procurement package and initiation of action.

A system for reviewing prime contractor's procurement systems, an alternative to review and approval of individual transactions, permits contract specialists to devote more time to processing new procurements.

Procurement offices have been augmented and support of program offices at the front end of the procurement cycle has been increased, thus reducing the time to place contracts.

More authority has been assigned to procurement activities and dollar levels for headquarters approval have been increased, thus eliminating several time-consuming steps.

A new solicitation review process is accelerating the procurement process.

Training has been provided to procurement personnel to upgrade their skills. Field offices have received onsite training.

An automated integrated procurement management information system has been initiated to provide better visibility for workload planning and execution. Phase one has been completed and the second phase is scheduled to be completed in September of this year.

GRANT APPLICATIONS

Mr. Murtha. Could I ask about the grants?

How long does it take you to process a grant? As an example, a gasification grant if somebody wants to gasify a work in a project; how long will it take you to process that?

Dr. White. We would do well to do it under 6 months.

Mr. Murtha. How long would it take?

Dr. White. It has taken 6 and sometimes longer.

Mr. Murtha. I am sorry. How much does it cost for the individual company to process it? I went out to EPRI in California last year with an electric company from my area and they wanted to get involved in a small gasification project that applied just to their coal, direct heating, but they wanted to use gasification because of pollution problems.

The proposal would cost between $250,000 and $300,000 for a very small plant, and so they dropped out of the competition because they felt it wasn't worth that kind of expenditure for an ERDA grant.

Dr. White. For a small operation that doesn't sound like the right number. If you are going to bid on one of the larger demonstration plants, however, you will get into that kind of money to prepare the

proposal. For a small project a businessman can write a letter if there is any chance for a few dollars.

Mr. MURTHA. Say you wanted to have a broad application rather than have a big demonstration plant, the small applications of individual gasification to a particular installation. How long would it take an organization to write to you, you would send them the appropriate advice or consultation, and how much would it cost for them to get something like this through?

Dr. WHITE. We have had a number of such small projects that have gone through our coal conversion division. I would like to ask Dr. Neuworth.

Dr. NEUWORTH. We got some of those through in 6 months.

Mr. MURTHA. How much did it cost the company?

Dr. NEUWORTH. I couldn't tell you. The $200,000 figure sounds way too high.

Mr. MURTHA. What kind of grant are you talking about?

Dr. NEUWORTH. We funded in the neighborhood of a couple million dollars per project, using contracts. There were six, about three of which are already funded.

Dr. WHITE. Those are moved much more quickly. They are much less complicated. I would doubt if they cost more than $5,000 to make a proposal.

A REGENERATIVE BRAKING INVENTION PROPOSAL

Mr. YATES. I should tell Mr. Duncan that prior to your coming in we were talking about inventions and how to handle inventions, and I told them about your accumulator invention. I don't know that I explained it properly. They were able to supply the lack of knowledge that I had. They called it regenerative braking.

Mr. FRI. That is a possibility. There is something called regenerative braking.

Mr. DUNCAN. I was interested in Dr. White's statement you can get all the information you need with a 13-cent stamp. I have had two problems. Frankly, the fellow that showed up in my office 1 day on this regenerative braking system—or energy storage is what he calls it—I though was a nut and I didn't want to take my time talking to him. I figured you must run into a lot of those people. But then I always think I am going to talk to the nut because maybe he is the guy who has found Utopia. I found out he had submitted his proposal to your Energy-Related Inventions Division and in accordance with your ordinary techniques you referred him to the National Bureau of Standards for an appraisal of his invention. The NBS has reviewed about 4500 of these and put its stamp of approval, which I assume means it certainly bears further examination and investigation and research and development, on only 27.

Mr. FRI. That is correct.

Mr. DUNCAN. His was one of those 27. He had at this point run into a complete stone wall of frustration. You finally wrote a letter disputing the Bureau of Standards, saying savings that I think indicated about a good 50 to 100 percent savings in fuel and came up with an esti-

mate that you could only save 3 percent fuel. Because it didn't meet your criteria of at least an 8 percent fuel savings over competition, you weren't interested in it. Here the Bureau of Standards had said 50 percent. There was no point-by-point rebuttal of the Bureau of Standards analysis.

Finally a few Senators and Congressmen began writing letters and in the meantime he was able to acquire enough venture capital to take two Ford Granadas and put his inertial storage system on one but not on the other. Incidentally, this system replaces the transmission with hydraulic accumulators, one for each wheel. The deceleration power utilizes a hydraulic pump which puts oil into these accumulators under pressure. As you decelerate, your engine goes off so you are not burning your fuel or running your engine during this total one hour it took me this morning to travel 9 miles. Then, when your light changes and you start out, you open a valve and that pressurized oil starts your car up and your engine comes back on.

He had run a test 2 or 3 years ago in Florida and it showed 51 percent savings. The Granada he made a movie of. He ran the vehicle over the same route, the same number of stop signs, et cetera, and it took exactly one half as much gasoline to run that route with the hydraulic accumulator as it did with the conventional transmission.

Mr. REGULA. This is effective in city-type driving is that correct?

Mr. DUNCAN. That is exactly right. It would not be very useful if you had over-the-road vehicles, but they tell me that on these fuel figures they weight at least two-thirds of any vehicle to be driven into the city as against one-third out.

Mr. REGULA. What is the cost of the system?

Mr. DUNCAN. He says depending on how it calculates, either $50 more to put his system on or $50 less. It is comparable in cost. Weight is comparable. You are not saving much weight. The rig he ran the other day did not take the driveshaft out. It would be useful on taxicabs, on buses, on mail vehicles, and he has the Post Office Department interested in converting on an experimental basis some of their postal vehicles. There are two bus systems in Portland who would love to put them on if they could get a little help out of ERDA to get them installed. I just don't know what is necessary, and now I am told that you are going to test it. But let me see what you say.

At least if the newspaper article on April 5 is right: "We don't expect to find much energy savings at all."

That is a hell of a way to start a test. It reminds me of the time I went in court and the judge said, "Duncan, what are you trying this case for? You can't possibly win it." The fact is, by 4 o'clock that afternoon I had a verdict for me.

"We never said the darn thing wouldn't work." I don't know the intonation of the man's voice when he referred to it as the darned thing. It might have been a simple colloqualism, but it seems to me that there is inertia down there that this inertial storage device can't quite overcome.

AN INVENTION TO RECOVER METHANE FROM MINES

I want your comments on this, but I want to call one more thing to your attention because there is another guy in this very prolific, well

educated area that I represent who came up with a device to recover methane gas from coal mines. He played around with ERDA for I don't know how long. I couldn't get anywhere with them. He has a little rig, portable, that he takes around with him. He doesn't care whether you have pipelines to pick up this gas or not. He slant drills and picks up this gas and then purifies it with some kind of temperature process. Apparently the impurities boil off or the good stuff, anyway, he puts into a cryogenic truck, pipeline quality gas, which he hauls to the nearest town and sells.

He was running into nothing but frustration. He finally now has called me. He has all the capital he needs from private sources, about $4 million I understand, and he is on his way now to a couple of demonstrations with private capital. Frankly, I would rather have it that way.

Mr. FRI. So would we.

Mr. DUNCAN. But I cannot help but feel that the thing we have set up here really isn't working. Do you have any comments at all?

OBJECTIVES OF ERDA'S INVENTIONS PROGRAM

Mr. FRI. Let me make three comments. We count it as a success when the private sector will fund a new energy activity.

Mr. DUNCAN. But surely not by frustration.

Mr. FRI. One of the reasons we set up fairly rigid project selection criteria is to screen out those projects that do not deserve Government support because they are likely to be successful enough with private support. We have had several companies including large ones, who have been through our selection system, and have withdrawn proposals because they realize they can make a profit on them and they didn't want us imposing all our patent clauses.

Mr. DUNCAN. I don't argue that at all.

Mr. FRI. That is one aspect of it. We cannot provide Government support to every proposal that comes in. Second, it is true that we get an enormous number of people coming in with bright ideas and it is very difficult to sort out the ones we should be funding.

Mr. DUNCAN. That is why you use the National Bureau of Standards?

Mr. FRI. That is the inventor program. In addition to the inventor program we have a very large number of unsolicited proposals that don't go the inventor's route. They come in and they are not paper ideas. They are like your fellow with the methane from coal beds idea where he has a working model. We have hundreds and thousands of those types of proposals too.

It can be very frustrating for us to sort through all those things. It takes time, more time than it should.

On the specific idea of inertial storage, the only information I have is that that is under evaluation in our conservation office and they are before you tomorrow. We will make sure that they have the story on that specific device when they are here.

NUCLEAR WEAPONS PROLIFERATION

Mr. FRI. The earlier question was how would a terrorist or an other person go about converting plutonium into a bomb. It boils down to

two questions, the amount of time it would take and the reliability of the device. No terrorist is going to be able to build a fully developed weapons capability. Most small countries couldn't. So what we are talking about is the possibility of building low yield explosive devices, not sophisticated things you put on top of missiles.

If the group, whether it is a subnational group or National Government, is prepared to take the time before the diversion of the material to build all the other necessary components of the device and then divert material, it is not an overly complicated process.

Mr. McDade. You said if the group is prepared to take the time and spend the money. Can you tell me what kind of time, what kind of money?

Mr. Fri. If they were planning ahead, they would easily require several months.

Mr. McDade. How long would it take?

You said if they were prepared to spend the time to build the facilities.

Mr. Fri. No; they wouldn't have to build facilities. You can build the components of an individual device without large facilities. The difficult aspect is to get their hands on the plutonium that can be reprocessed. Reprocessing requires some sophistication in shielding, but it is a well-known chemical process and a device theoretically could be fabricated.

Its reliability would be in question. It would probably go off. Whether it went off with the design yield or not would be a question, but it would go off.

Mr. McDade. Could I take you on a difficulty scale of 1 to 10? If you had the plutonium around and you were one of those groups, your difficulty in producing an explodable device might rise to 2, or maybe 3, let's say for purposes of assumption, whereas if you had to go through the channels that India or China or somebody else went without the material you might rise to 10 on the difficulty scale. Is that right?

Mr. Yates. We better come back.

[Brief recess.]

OBLIGATION OF FOSSIL ENERGY FUNDS

Mr. Yates. Let's go back to prosaic stuff.

Of your unobligated amount of funds, how much is presently in the procurement process? How much of your funds are unobligated? Maybe we ought to find that out first.

Mr. Greer. Let me start with some statistics. In the fossil program we have, including the carryover, some $545 million in operating funds available to us.

Mr. Yates. You have $545 million. What percentage is that?

Mr. Greer. That is the total availability.

Mr. Yates. Total operating expenses?

Mr. Greer. Yes. We have obligated $172 million of that as of the end of March.

Mr. Yates. $172 million. What percentage is that?

Mr. Greer. It is about one-third.

Mr. Yates. About a third.

How much are you going to carryover of that? What is your guess?

Mr. GREER. My guess is that we are going to probably have a carryover in the $100 million, $150 million range again, but I am not sure that that is an unreasonable carryover, Mr. Yates.

Let me explain. The Fossil Divisions have made their programmatic judgments on the use of their availability. As it goes into the procurement process, it gets identified and set aside, essentially reserved for the procurement. Then it is really a question of whether we can get the procurement through by the end of the fiscal year or not, and we are working very hard to try to do that.

Mr. YATES. We want you to spend your money reasonably. You think you ought to spend it reasonably.

Mr. GREER. Again, the principal portion of the carryover this last year was associated with the eight big contracts where we are having some difficulty in getting patents resolved and agreeing to final terms and conditions with the companies. It is a very protected negotiation in those big contracts.

Mr. EVANS. Could I inquire what the carryover was from the last fiscal year?

Mr. YATES. I turn to page 506 of part 5 of last year's hearings and I read from the hearings:

> Mr. YATES. I want to talk about ERDA's capability for using funds. According to OMB's computer tapes, the total expenditures for ERDA from this subcommittee for fiscal year 1977 are projected to be $462,690,000. Of this total only $55,239,000, roughly 12 percent, will be spent from funds requested for appropriation in fiscal year 1977. The remainder will be spent from funds appropriated last year and from previous years. Why then should we appropriate all the money?

Is it the nature of the process that ERDA goes through in order to obligate its funds that makes it so difficult to fit your expenditures within a fiscal year?

OUTLAY PROJECTIONS

Mr. GREER. There are two issues wrapped up here. With the OMB computer tapes, we are talking about outlays, that is, the actual paying out of the cash as the work is performed, rather than obligations, which is the utilization of appropriations made available to us to enter into contractual obligations. Outlays traditionally lag the obligations, especially in big hardware contracts.

Mr. YATES. What are your outlays going to be this year? Do you have any idea?

Mr. GREER. Yes; we think our outlays this year in the fossil energy field are going to be somewhere between $375 million and $400 million.

Mr. YATES. What percentage is that?

Mr. GREER. Of the obligations it would be about 90 percent of the total obligations.

Mr. MCKAY. Is this where we found that $5 billion or $11 billion we didn't know how we saved in the Government because you guys have been holding on to it?

Mr. GREER. No. but that is part of the problem. The other causing factor is that traditionally the estimates for outlays are usually greater than the capability to perform and so that with any slippage anywhere in the program planning or procurement process, you will get part of the $11 billion.

COSTING RATES

Let me just come back. We had estimated at the time we gave you this budget that fossil would cost out about $422 million, and there is still a reasonable chance that they will come close to that figure. Through March they were underrunning somewhat—about $17 million below their projections. If you projected that for the entire fiscal year, they would underrun some $35 to $40 million.

Mr. YATES. Last year on page 508:

Let me follow up my previous question with another one. In your justifications, you show a projected end of year obligated but unexpended balance rising from $193 million at the end of fiscal year 1975 to $437,991,000 at the end of fiscal year 1977. Obligated but unexpended. What does that mean?

Mr. GREER. It means there is going to be a lot of money out in contracts for which the work is yet to be done.

The same type of approach. It is apparently the nature of your contracting, isn't it, really?

Mr. GREER. Yes, sir, it is partly that, but you will see the expenditures rise each year.

Mr. YATES. Last year you speeded up, but so far you haven't this year.

Mr. GREER. I think there is quite an increase in the costing. Costs last year were about $238 million, and if we cost on the order of $375 million or $400 million this year there is about $125 million in real growth and work.

APPRAISING DIFFICULTY IN FABRICATING NUCLEAR WEAPONS

Mr. YATES. Mr. Fri, will you go back to telling Mr. McDade how to make a bomb?

Mr. FRI. I think we were talking about the level of difficulty scale.

Mr. MCDADE. Let's establish a few things because I am trying to learn about this process. Any nuclear technology we have that exists produces byproducts which can be made into atomic weaponry.

Mr. FRI. Essentially correct.

Mr. MCDADE. Now we shift over to the plutonium side, and am I correct in saying to you that the only difference there is degree of difficulty?

Mr. FRI. Do you mean trying to get plutonium out of spent fuel versus having the reprocessed material readily available?

Mr. MCDADE. Of all the various types of technologies that exist, when you get to the breeder reactor which produces plutonium, is the only difference in the availability of a radical group to make that bomb using any of the existing technology and the breeder reactor one of degree of difficulty? Is that the only problem?

Mr. FRI. I think that is essentially correct, but go on.

Mr. YATES. Essentially correct. What are the differences?

Mr. FRI. If you are going to go out and develop yourself a first class weapons capability——

Mr. MCDADE. No: no. We are not talking about ICBMs and all the rest of it. We are talking about the creation of an explosive atomic device. Right?

Mr. FRI. All right.

Mr. McDade. Aren't we?

Mr. Fri. That is what you are talking about. There are two things that a radical group would have to know. One is the basic theory of getting a critical mass together in a short enough time to have an explosion. The physics of that are quite well known, and the mechanics of actually getting the critical mass together are, in theory, also not too complicated.

Mr. McDade. Under any byproduct from any technology?

Mr. Fri. For any material with enough neutron activity to create the critical mass.

Mr. McDade. As I sit here, an uneducated layman——

Mr. Fri. Then let's stick with plutonium. It is a lot easier. The only difference is whether you happen to be using U-235 or plutonium or conceivably some other material, but most of them behave roughly the same way.

The other degree of difficulty involves getting the plutonium itself. If you have a spent fuel rod, burned in a commercial power reactor, it requires shielding because it contains a lot of fission products that create radiation hazards. But the chemistry of dissolving that rod in nitric acid and using certain organic solvents to separate and precipitate out the plutonium is not terribly complicated. If you are dealing in small batches, it does not require large-scale equipment.

Plutonium material you get that way will be somewhat contaminated by odd isotopes that aren't particularly desirable for weapons purposes. Consequently if you design a device using such material, it may go off with a lower than design yield. It may not make as big a boom as you would otherwise expect, or it may be bigger, but the chances are very good it will go off.

If you are a terrorist, and you just cannot make something that will credibly go off, it is not possible to exploit a situation. But if we know that the terrorist actually had material, and that the terrorist seemed to have enough scientific know-how as to the basic theory and had a little mechanical ingenuity, it would not be possible for me to advise the President that this device wouldn't work.

Mr. McDade. I hope you have answered my question.

Mr. Duncan. But the example you just gave us is the product of our present commercial nuclear industry supplied by light water nuclear reactors, isn't it?

Mr. Fri. That is correct.

Mr. Duncan. So that what you have said is that the products, that the price in it is going to encourage the development of many more, poses the same threat that a breeder reactor would.

Mr. Fri. When looking at it from purely a terrorist viewpoint, if you start either recycling plutonium back into a light water reactor, or if you are going to breeder reactors, you wind up with fresh fuel elements that have plutonium in them and they are easier to handle than the spent fuel elements because they are not irradiated. They don't have the high-fission product concentrations to handle. It doesn't require additional shielding and you don't have to worry about separating out the fission products. Consequently in principle it is somewhat easier to handle than a spent fuel rod.

Mr. Duncan. What Mr. McDade is trying to get at is true. It simply becomes slightly more difficult to use the spent fuel rod from

our present technology than to use the plutonium that is the product of the fast breeder reactor.

Mr. FRI. From the standpoint of the terrorist threat that is correct. The terrorist threat is clearly something that one needs to have safeguards against.

Mr. DUNCAN. Regardless of the technology used?

POSSIBLE PLUTONIUM DIVERSION

Mr. FRI. Regardless of the technology that is used. If you go beyond the terrorist threat, there is also the possibility of the national diversion of material. When you start shipping around fresh fuel that has plutonium in it, you wind up with large quantities of plutonium in international commerce. This material is embedded in a fuel rod, but nonetheless there is large quantities in international commerce. If you believe the scenario of national diversion where a government more or less overnight either changes its mind about being a nice guy, or of there is a revolution, or whatever; in principle it could latch on to a very large quantity of plutonium-bearing material and proceed to make a fair number of explosives.

NUCLEAR PROLIFERATION

Mr. MCDADE. You go back to the old problem too, don't you? That some country if they decide to, as India did, or China, or Lord knows how many, given a certain level of wealth and sophistication, they can do it too. They don't need the plutonium to do it. They can do it?

Mr. FRI. That is correct. A nation with any degree of sophistication, that sets out to develop a weapons capability, is willing to take that kind of time and money and, more importantly, wants to take the international political heat, can in principle go off and do it, no question about it.

Mr. MCDADE. That is why I was trying to hit you with this mythical graph.

Mr. DUNCAN. So then the difference really that you are telling us about is simply the fact that our resources in uranium are finite and, therefore, there is the finite limit to the threat of making nuclear bombs, whereas if you have a breeder reactor your fuel sources are infinite and, therefore, you have increased the threat, is that correct?

Mr. FRI. Yes; roughly, that the spent fuel, given a once-through cycle, is finite in amount and is also fairly easily accounted for and protected in a security sense. When you start breeding plutonium you have much greater inventories and some parts of that inventory are in more easily accessible forms.

Mr. DUNCAN. Yes; you have a greater inventory, so our difficulties of acounting for it are greater simply because of the size, but it is just as susceptible to accounting, is it not, in large quantities as in small? The product is predictable, is it not?

Mr. FRI. It is susceptible, but the accounting problems get to be pretty fantastic. If you are going to protect against bomb quantities getting loose you have to account for material down in the kilogram range. With the breeder reactor, you start producing hundreds of metric tons of plutonium all over the world, and the amounts that you have to account for becomes kind of a miniscule percentage of the total amount in circulation.

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THE ADMINISTRATIONS NUCLEAR ENERGY POLICY

Mr. DUNCAN. But don't we still have uranium resources measured in 1 million or 2 million tons?

Mr. FRI. Yes; but the uranium itself lying in the ground is not a problem.

Mr. YATES. The lack of it is the problem.

Mr. MCDADE. Isn't that the very reason that you have friendly nations, allies like the Japanese, French, et cetera, very, very short on energy, period, devoted to the breeder reactor because it solves their shortage of uranium?

Mr. FRI. That is correct.

Mr. MCDADE. So we have a real difficult problem with our allies. They are not in the fossil fuel race. They have been out of it for a long time.

Mr. FRI. It is a very serious problem. It is one of the trickiest kinds of problems there is because if you let the whole system go on without any control at all, it is my judgment you would wind up with more reprocessing plants in more countries than is justified by anything approaching legitimate needs for energy or by economics. The name of the game is how do you limit the number of sensitive reprocessing and enrichment plants in an international framework that guarantees energy supplies to all the people with legitimate needs for energy. That is an exceedingly tricky structure to create. Basically what the President is saying is before we go sailing off in an uncharted sea let's map the course to make sure we know what we are doing because the consequences of making a mistake in this field are very serious. This is complicated by the fact that some nations have already taken the initial steps in establishing breeder reactor systems.

Mr. MCDADE. Would it have been easier to do than saying we will all be out of oil by 1985?

INTERNATIONAL BREEDER REACTOR TECHNOLOGY

Mr. DUNCAN. The last time you referred to this line of argument you said it would be impossible for us to persuade other nations to stop their efforts to catch up with our technology if we were going ahead full blast. Now, am I correct that my assumption that Germany and other nations in the world are not behind us but ahead of us in breeder technology?

Mr. FRI. Well, France is cleary ahead of us in the construction of demonstration plants. Whether they are ahead of us in the basic technology is a different question, but they have clearly well-developed programs.

Mr. DUNCAN. It isn't a question of us deterring them from catching up with us?

Mr. FRI. No. It is a question of us catching up with them. That was my point. Take the reprocessing program, for example. If we were to say that we are going to go ahead with commercial reprocessing plants and build that industry up, and that we would like the rest of the world to stop so we can worry how it is going to work worldwide, we would be viewed as trying to get the rest of the world to pause while we caught up with them. This action would be viewed as a commercial ploy and have no effect whatsoever.

Mr. DUNCAN. Wasn't it West Germany that peddled one of these reprocessing plants to Brazil?

Mr. FRI. Brazil, yes.

Mr. MCDADE. And France to Korea, I think.

Mr. FRI. Pakistan.

Mr. MCDADE. And the President's theory is they will stop doing that if we stop something at Clinch River, right?

Mr. FRI. I think the President's theory is that our arguments in asking them to stop will have no force if we are plunging ahead.

Mr. MCDADE. We are not selling to anybody?

Mr. FRI. No; we are not. Our stopping may not persuade them to stop by that fact alone, but our planning ahead will certainly not persuade them to slow down.

Mr. MCKAY. It really didn't stop anybody when we had the atom to begin with, did it? France was plunging as far ahead as their economics would allow her.

Mr. YATES. We made that available to France, didn't we?

Mr. FRI. I am not sure of the history of that.

Mr. MCKAY. And every nation has been pushing whether we stopped or started.

Mr. FRI. There is an interesting historical note. Back at the time of atoms for peace, there was a feeling that some international structure for supplying nuclear power for legitimate energy, such as the one we are trying to develop today, needed to be developed. The nations of the world wouldn't buy it. Some of them were too interested in the weapons capability, and that concept was not pushed hard enough and it fell part. In some sense we are revisiting that scene now.

COMPLEXITY OF PLUTONIUM WEAPONRY

Mr. YATES. Mr. McDade.

Mr. MCDADE. If it is not a fair question tell me because I am not trying to trap you. Let's assume—I am back to my degree of difficulty from 1 to 10—10 was the most difficult way to build a bomb, and that would be, let's say, the process by which we did or were mining the uranium, or by which India did, or the Chinese did. Ten was the top. If you have a breeder program going, plutonium, much more widely accessible in the world, where in that level of one to ten, ten being the most difficult, would the degree of difficulty lie in creating a bomb?

Mr. FRI. You mean by a terrorist group, for example?

Mr. MCDADE. Well, if we want a new one——

Mr. FRI. Let me do it this way. Let me modify your scale.

Mr. MCKAY. Idi Amin.

Mr. YATES. Combine them both.

Mr. FRI. If 10 is the way we did it——

Mr. MCDADE. I mean we were the first. The Indians I assume learned a few things and the Chinese might have, so I don't want to take it from kind of a stone age degree of difficulty. I am sure the technology moved along using conventional, so pick a few fairly——

Mr. FRI. Assume 10 was the degree of difficulty in our initial efforts. If plutonium material was available and knowing what everybody knows from the open literature the degree of difficulty for a crude device would be 4 to 5 on the same scale.

MAJOR FACILITIES AND RESEARCH CONTRACTS

Mr. YATES. Let's go back to bookkeeping. For your major facilities and major research contracts, which are over $5 million, using that as your scale, would you place in the record information for each contract as to how far into the future your 1977 funds will allow operation?

Mr. GREER. Yes, sir.

Mr. YATES. Can you do the same for 1978?

Mr. GREER. Yes, sir.

[The information follows:]

STATUS OF MAJOR FOSSIL FUNDED PROJECTS

The attached Status of Major Project Funding for Fossil Energy has been prepared to reflect projects involving contracts over $5 million as directed by the committee. March 31, 1977 was used as the cutoff date of currently active contracts.

The fiscal year 1978 budget request was prepared recognizing fiscal year 1977 procurement plans and availability of funds, as reflected in the attached summary, and the fiscal year 1978 BA request is the required level to continue ongoing projects.

Since the committee directive was to provide information on fossil contracts over $5 million, a considerable portion of our program is not described in the presentation. We have, however, attempted to show the funding for those areas not included in the major projects at the subprogram level as dedicated funds and minor contracts. This includes work at the ERC's and National Labs and for contracts under $5 million.

STATUS OF MAJOR PROJECT FUNDING—COAL PROGRAM

[In thousands of dollars]

Project/contractor and number	TEC	Prior year cumulative obligations	Fiscal year 1977 obligations: Actual: Through Mar. 31, 1977	Fiscal year 1977 obligations: Actual: Funded through	Fiscal year 1977 obligations: Estimated additional to Sept. 30, 1977	Fiscal year 1978: Unfunded balance	Fiscal year 1978: Required budget authority for project
LIQUEFACTION [1]							
Ebullated-bed (H-Coal) pilot plant	142,626	$49,946	20,425		1,303	70,952	26,000
HRI—1544		32,625	0	April 1977	0		
Ashland—2260		15,302	16,740	October 1977	0		
HRI—2547		0	3,685	September 1977	0		
All other		2,019	0		1,303		
Fixed-bed hydrogenation (Synthoil) PDU	87,072	34,172	5,277		5,790	41,833	11,000
Foster Wheeler—0008		17,525	3,000	May 1977	2,674		
All other (includes in-house R. & D. at PERC)		16,647	2,277		3,116		
Zinc chloride catalyst PDU: Conoco—1743	10,280	2,635	1,000	July 1977	3,020	3,625	2,000
Solvent refined coal (SRC) pilot plant	[2] 170,173	62,742	15,242		4,100	88,089	15,000
Pittsburgh & Midway—496		59,742	12,500	March 1978	4,100		
Southern Co. Services—2270		3,000	2,742				
Donor solvent extraction pilot plant: Exxon—2353	134,000	6,370	0		2,000	125,630	30,300
Clean metallurgical coke/liquids PDU: United States Steel—1220		[3] 8,337	0		[3] 2,400	0	[3] 0
Cresap test facility: Fluor engineering—1517	88,273	43,043	3,320		6,000	35,910	12,500
Dedicated funds and minor contracts			2,786		8,303		10,200
Total liquefaction			48,050		32,916		107,000

See footnotes at end of table.

STATUS OF MAJOR PROJECT FUNDING—COAL PROGRAM—Continued

[In thousands of dollars]

Project/contractor and number	TEC	Prior year cumulative obligations	Fiscal year 1977 obligations: Actual: Through Mar. 31, 1977	Fiscal year 1977 obligations: Actual: Funded through	Fiscal year 1977 obligations: Estimated additional to Sept. 30, 1977	Fiscal year 1978: Unfunded balance	Fiscal year 1978: Required budget authority for project
HIGH-BTU GASIFICATION							
HYGAS pilot plant	39,870	37,909	1,961		0	0	0
IGT—381 and—1221		34,383	0	Completed			
IGT—2434		3,562	1,961	June 1977			
CO_2 acceptor pilot plant	33,181	30,618	2,563		0	0	0
Consol—415		22,121	0	Completed			
Conoco—1734		8,497	2,563	August 1977			
Bi-Gas pilot plant	103,000	45,305	2,706		7,094	47,892	11,000
BCR—1207		41,305	2,706	August 1977	7,094		
BCR—324		4,000	0	Completed			
Self-agglomerating burner PDU: Battelle—1513	16,204	12,272	0	July 1977	1,927	2,005	1,500
Synthane pilot plant	89,250	36,868	5,653		6,617	40,112	14,500
Combustion Engineer—CO2-0003		16,258	4,117	March 1977	4,801		
Rust Engineer—CO2-4038		13,689	0	Completed	0		
All otner (include in-house R. & D. at ERC)		[4] 6,921	1,536		1,816		
Steam-iron pilot plant	29,047	21,940	960		3,640	2,507	[5] 5,700
IGT—1518		16,711	0	Completed	0		
IGT—2435		5,229	960	August 1977	3,640		
Dedicated funds and minor contracts			1,332		16,742		18,500
Total high-Btu gasification			15,175		36,020		51,200

LOW-BTU GASIFICATION [1]							
Fluid-bed, 2-stage, gasification PDU: Westinghouse—1514	32,994	22,110	1,500	October 1977	2,613	6,711	5,000
Entrained-bed gasification PDU: Combustion engineering—1545	13,739	13,739	0	September 1978	0	0	0
Combined cycle test facility: Commonwealth Edison—2352	116,000	0	0		31,050	84,950	28,000
Molten salt PDU	10,445	10,160	285		0	0	0
Rockwell—2342		5,845	3,885	December 1979	0	0	0
All other		4,315	−3,600				
Hydrogen from coal facility: (proposals under evaluation)	87,000	0	0		5,000	82,000	18,000
Gasifiers in industry	[6] 14,510	0	1,732		2,722	[6] 10,056	10,000
Pike Co.—2570			0		1,200		
Land of Lakes—2572			0		1,000		
University of Minnesota—2571			1,137	September 1977	0		
Accurex—2573			595	September 1978	0		
General refractories			0		522		
Dedicated funds and minor contracts			2,558		8,591		12,900
Total low-Btu gasification			6,075		49,946		73,900
DIRECT COMBUSTION [1]							
Fluidized-bed boiler, 30 MW: Pope Evans—1237	42,600	20,444	2,214	June 1977	1,935	18,007	4,000
Industrial applications	[6] 39,267	12,151	5,368		2,800	[6] 18,948	10,000
Georgetown University—2461		2,101	0	March 1977	1,600		
Combustion Engineering—2473		500	5,368	March 1981	0		
Exxon—2471		3,275	0	May 1980	0		
Battelle—2472		3,397	0	June 1980	0		
Fluidyne—2463		2,878	0	June 1981	0		
Babcock & Wilcox—2470		0	0		1,200		
Fluidized-bed combined cycle plant, 13 MW	45,000	11,885	7,482		2,400	23,233	7,000
Curtiss-Wright—1726		7,500	6,000	June 1978	2,400		
Burns & Ros—2371		1,385	0	November 1977			
General Electric—2357		2,900	1,482	June 1978			
Coal-oil mixtures	[6] 27,377	9,937	742		5,020	[6] 11,678	7,000
Accurex—2563		0	0		500		
New England Power—2564		2,547	0	July 1977	1,446		
City Public Service—2425		6,303	0	do	1,733		
Interlake Inc.—2562		0	0		516		
All other		1,087	742		825		

See footnotes at end of table.

STATUS OF MAJOR PROJECT FUNDING—COAL PROGRAM—Continued

[In thousands of dollars]

Project/contractor and number	TEC	Prior year cumulative obligations	Fiscal year 1977 obligations: Actual: Through Mar. 31, 1977	Actual: Funded through	Fiscal year 1977 obligations: Estimated additional to Sept. 30, 1977	Fiscal year 1978: Unfunded balance	Fiscal year 1978: Required budget authority for project
Dedicated funds and minor contracts			8,283		37,986		25,200
Total direct combustion			24,089		50,141		53,200
MAGNETOHYDRODYNAMICS[7]							
Preliminary engineering			5,228		6,232		10,613
Arnold Engineering Development Center—1542	6,645	5,936	650	November 1977	0		
University of Tennessee Space Institute—1760	8,151	4,789	816	March 1977	1,513		
All other			3,762		4,719		
Component development and testing			11,619		22,056		23,913
Avco—2519	19,773	0	3,362	September 1977	0		
Kaiser Industries—1600	23,280	1,000	3,000	April 1977	16,000		
All other			5,257		6,056		
Dedicated funds and minor contracts			6,188		7,564		11,274
Total magnetohydrodynamics			23,035		35,852		45,800

ALL OTHER COAL [8]						
Technical support contracts, multiple subprogram funded			[9] (3, 863)		[9] (2, 538)	
TRW Inc.—2213	6, 377	2, 169	3, 563	September 1977	0	
MIT—2295	10, 485	2, 173	300	March 1977	2, 538	
Advanced power, advanced research and supporting technology, and demonstration plants subprograms			32, 288		109, 484	116, 400
Total coal program			148, 712		314, 359	447, 500
PETROLEUM AND NATURAL GAS [10]						
Micellar polymer flooding	25, 785	20, 785	512		7, 127	12, 500
Marathon oil—CO2-4208	(14, 000)	6, 000	0	July 1977	2, 000	
All other		14, 785	[11] 512		[11] 5, 127	
All other Petroleum and Natural Gas Program			12, 601		26, 059	63, 600
Total petroleum and natural gas program			13, 113		33, 186	76, 100
Total in situ technology program			10, 261		25, 499	39, 000

[1] Government share only.
[2] Includes Wilsonville support project.
[3] Project will be completed with funds provided in fiscal year 1977.
[4] In-house R. & D. and minor contracts prior to fiscal year 1976 are not included.
[5] Provides for first full year of operation.
[6] Estimated total value of contracts.
[7] Total value of major contracts, Government share only.
[8] Total value of contracts, Government share only.
[9] Obligations included in respective subprogram totals.
[10] Total value of all active Micellar Polymer Flooding contracts.
[11] Includes in-house R. & D. and ERC's and national laboratories.

Mr. YATES. Now, we have a question prepared here and I would hope that it is all your program. Which of your fossil energy programs will be contributors to President Carter's energy goals for 1985? I would assume all of them, wouldn't you?

Mr. FRI. The magnetohydrodynamics program might not have a major impact by 1985.

Mr. YATES. Would Senator Mansfield have agreed to that?

Mr. FRI. I think even Senator Mansfield would have agreed. I think he was looking at 1987 for a commercialization decision.

Mr. MCDADE. Did you scrap liquefaction?

Dr. WHITE. That will be a very important backup for the 1985 and later time frame.

Mr. MCDADE. Are we assuming this question includes equivalent pricing at that time?

Dr. WHITE. Yes.

Mr. MCDADE. OK.

Mr. MCKAY. To follow up his question, I think you said this morning looking at 1985 and 1990, that your programing would not include pushing liquefaction? Is that correct?

Mr. FRI. Our liquefaction program includes the solvent refined coal process which produces a boiler feed which is not quite a liquid, which I think will be contributing in that time frame. The more advanced synthetic crude from coal is further off.

Dr. WHITE. I think one of the things I would like to go into is it may be a very critical hedge because either we find the environmental problems on shales, water problems, and the likelihood our imports will be reduced. Coal liquids are the only source of liquids for our transportation sector.

Mr. MCDADE. At $35 a barrel we have had testimony, have we not, that oil shale would come in at about $15, $16.

Dr. WHITE. But as I said, if you want protection against the possibility of being unable to use shale for reasons other than economics, coal is the one thing you have to fall back on for liquids.

Mr. MCKAY. But given that scenario, you said earlier today, and at least I had the impression from what you said, that because of the price and other things you are going to have liquefaction research down here at the bottom somewhere on the shelf until you get pressed. So if that is the case you won't be ready for the fallback, if that happens. Isn't that true?

Mr. FRI. What I said, and certainly what I meant to convey, was we wouldn't be pushing liquefaction into half-billion dollar or billion dollar demonstration plants with great urgency. However, for the reasons that Dr. White mentions, I think we ought to have a handle on that technology, including some working plants, particularly the SRC plant which is included in our amendment.

Mr. MCKAY. But you are saying you are willing to go the route on all the other resources to get all our energy things up, but this one you decided to set aside.

Mr. YATES. And if you will yield, before he answers, why do you want another $12 million for the solvent refined coal demonstration plant?

Dr. WHITE. The pilot plant is already running, and we are trying to find out if we can apply the SRCII process to a larger plant. The SRC demonstration plant would be aimed at converting high sulfur eastern coal to an almost sulfur-free clean burning fuel.

Mr. YATES. You are talking then about putting your billion dollar plants on the back burner or turning the back burner off?

Dr. WHITE. We are not on the front burner on liquefaction.

Mr. YATES. And you are not going to put it on there.

Dr. WHITE. We are not planning to.

Mr. MCKAY. You don't feel you need a backup reserve to oil shale and the other things you are talking about?

Dr. WHITE. We will have the technology, and it is just a case of whether you want to demonstrate it at full scale.

Mr. YATES. At the cost.

CURRENT STATUS OF ERDA LIQUEFACTION RESEARCH

Mr. MCKAY. Haven't you found in your research that even though you have the beginning and you had a few model demonstrations, that quite often when you get out to the commercial it isn't there? So then if you don't know that——

Dr. WHITE. We have three or four processes to draw on. SRC is going through the pilot stage, H-Coal, which is now being built, donor solvent, which is coming right along, and there is Synthoil. We have a fair degree of confidence we will be able to go ahead commercially when we need to.

Mr. MCKAY. You think you will have the technology to move to liquefaction?

Mr. FRI. Those are not exactly bench scale units. They are essentially pilot plants, but they are not the great big demonstration plant operations.

Mr. MCKAY. But it is not uncommon to go from pilot plant to commercial size and have it go flat on its ear, because it doesn't work at that scale?

Mr. YATES. You haven't had that experience yet.

Dr. WHITE. We haven't had that experience yet.

Mr. MCKAY. That is what I am saying. The point is you may be counting on something you haven't got.

Dr. WHITE. Obviously we could have a greater degree of confidence if we had built a full-scale commercial one and had it run and let it sit there until we were ready for it.

STATUS OF THE U.S. COAL INDUSTRY

Mr. YATES. Let's talk about the coal industry now. You are backing up with coal, aren't you? We have an article that appears in the Akron, Ohio, Beacon Journal for March 20. You don't read all the newspapers I take it. Especially you haven't read the Akron, Ohio, Beacon Journal, right?

Dr. WHITE. True.

Mr. YATES. In the Akron, Ohio, Beacon Journal it says:

> The coal industry is dying. Since World War II, its share of the U.S. energy budget has fallen from 48 percent to 17 percent.
>
> But now, with President Carter touting coal and conservation as the best short-term answer to the energy problem, the industry is being asked to do an about-face.
>
> It won't be easy.

Carl Bagge, president of the National Coal Association, said recently, We lost most of our markets even before the environmental revolution began. There are fantastic sums of money being thrown at us by the Government, but we don't have the infrastructure to handle it all."

"The politicians seems to think we can be turned on and off like a spigot. We cannot."

I assume you fellows aren't politicians. I assume you will also agree with that.

Dr. WHITE. Yes, sir.

Mr. YATES:

Environmental, labor, money and transportation problems all will conspire against a quick rejuvenation of the coal industry, Bagge and others believe. The potential for rejuvenation is large, however.

Coal is to the United States as oil is to the Middle East.

But coal is without a doubt the filthiest and least convenient of the fossil fuels.

It is hazardous to mine it underground and damaging to the environment to strip mine it.

Water pollution results when it is mined; air pollution when it is burned.

Moving it from mine to market is a massive undertaking, especially considering the decrepit state of the railroads.

Compared to coal, oil and gas are a dream. That is why those two fuels now account for three-fourths of the energy we use.

And that is why conversion of coal to synthetic oil and gas is a main priority of the U.S. Energy Research and Development Administration (ERDA).

We found that it wasn't one of your main priorities for synthetic oil.

Mr. WHITE. If you look at the budget you will find a pretty significant amount of money.

Mr. YATES. You aren't very optimistic about that at the moment, are you? You can do it but are worried about the cost.

Dr. WHITE. Yes, sir.

ENVIRONMENTAL STANDARDS FOR COAL

Mr. YATES. But then what about the environment too?

"Coal is an environmentally atrocious fuel, flatly states Dr. William Johnson, director of George Washington University's energy policy project.

"The problems are twofold", Johnsson said, "strip mining and air pollution."

What are we going to do? Do you have your environmental man here?

Dr. LIVERMAN. Yes, sir; I am listening. Carl Bagge didn't say that.

Mr. YATES. No; he didn't say that. William Johnson said that. I don't think Carl Bagge was asked the question.

At any rate, what are you going to do about it? Are you going to put scrubbers everywhere?

Dr. LIVERMAN. Well there are alternatives to putting scrubbers on everything. For example, solvent-refined coal represents a technique for removing sulfur prior to combustion and fluidized bed combustion, in which limestone is injected directly into the bed, represents a technique for removing sulfur during combustion.

Mr. YATES. Do you agree with the President we have to move over to coal?

Dr. LIVERMAN. Yes, sir.

Mr. YATES. What are we going to do with environmental standards? Ease them?

Dr. LIVERMAN. I think we can live with the environmental standards in most cases. I agree with Congressman McKay here that I don't think you always need to install the best available control technology simply because it is available, particularly if you are using coal that allows meeting all the standards that are in existence. If scrubbers are required, certainly they will have to be put in. But I think if we work on the environmental problems aggressively and we work with the technology and work hand-in-hand we can prevent a lot of retrofitting. This is what we are doing with the fluidized-bed process we are now developing.

COAL TRANSPORTATION

Mr. YATES. Do you have to worry about transportation of coal?

Dr. LIVERMAN. Unless we build gasification or liquefaction facilities near the mine mouth, yes, you have to transport it.

Mr. YATES. So Dr. White isn't building them so fast. You are going to have to transport them?

Dr. LIVERMAN. We will have to continue to transport coal for quite some time.

Mr. YATES. How?

Dr. LIVERMAN. By rail.

Mr. YATES. FEA has to worry about transportation.

Dr. LIVERMAN. But we have to consider it I think in our policy considerations as well.

Mr. EVANS. Would the chairman yield on that question?

Mr. YATES. Mr. Evans.

COAL PIPELINE SLURRIES

Mr. EVANS. In examining the transportation problem, have you looked into, and if you have what has been your opinion of coal pipeline slurries?

Dr. LIVERMAN. I have not looked into that question. I don't know whether Dr. White has or not, but there is an enormous amount of opposition to it, particularly if you move coal by pipelines out of the West where there is a water problem.

Mr. EVANS. Is this item your responsibility to study?

Dr. LIVERMAN. That has not really been in our area of responsibility. We have touched on the edges of it.

Dr. WHITE. We had a study done for us which created quite a problem because of the group that did it, but there is no problem of technology. There is nothing to develop. It has been developed. It has been used commercially. It is being used commercially today. It is simply a matter of economics and institutional barriers which now exist against it and the very critical water problem that would certainly militate against going from the Montana-Wyoming area to either east or south.

Mr. EVANS. Would it come into your shop to examine the question of the economics of pumping water in and back having a closed circuit of waterflow?

Dr. WHITE. We have looked at that sort of economics in a casual way.

Mr. EVANS. Do you have an opinion on the economic visibility?

Dr. WHITE. Bill Grouse, didn't we look at that?

Dr. GROUSE. It is not too bad to pump water both ways. In some cases it may be cheaper than putting in rail lines. It depends on whether you have rail in or not as to what you do. But you have to put in a completely new system. Our studies indicate in some cases pipeline is cheaper and maybe pumping water both ways. There is no simple answer.

Dr. LIVERMAN. It clearly needs more study, much as the water problem we were discussing this morning.

ENVIRONMENTAL EFFECTS OF INCREASED COAL PRODUCTION

Mr. YATES. Do you have to worry about increasing coal production now that the President has placed the load on coal that he has?

Dr. WHITE. Yes, clearly.

Mr. YATES. Or does FEA do that?

Dr. WHITE. The actual work on removing institutional barriers is largely FEA's. We recognize, however, that there is not much point in having the technology if we don't have the coal.

Mr. YATES. What will be the environmental effect of producing and using over a billion tons of coal a year, which is our goal?

Dr. LIVERMAN. The environmental problems will be difficult and very tough if we don't put in place a well-rounded, meaningful environmental program and work vigorously instead of talking about it. It must be pursued as aggressively as we do the technology itself. Thus we have to get into the land reclamation issues and do so aggressively. I think it is important that every agency in town that has any stake in this game works so that we can get our act together.

Mr. MCDADE. In the sense of getting our act together this billion tons is about a 60-percent increase. I find that just a mind boggler, and I don't know who in ERDA but I wish he would raise his hand and tell me we are going to do this.

Dr. LIVERMAN. I think one of the reasons for the President's recommendation to create a Department of Energy is to get most of the acts together that deal with this question. The Bureau of Mines in Interior clearly has a lot to do, so does FEA.

Mr. MCDADE. To move a lot of boxes around in Washington is swell, but somebody is going to have to find a way to generate the capital to open a new mine, to buy the equipment, to find the miners, to make it safe, to get rid of black lung, to handle the water pollution problem, to handle acid mine water, to get rid of all of that, and it is enormous, and I just wonder who it is. Is that Dr. Schlesinger too?

Dr. LIVERMAN. That must be Jim Schlesinger.

Mr. YATES. But it is not ERDA?

Dr. LIVERMAN. Not ERDA alone.

Mr. YATES. You are watching sympathetically.

HEALTH, ENVIRONMENT, AND SAFETY

Mr. MCDADE. What part of it do you have?

Dr. LIVERMAN. ERDA is looking at the technology. My part is concern for the health, environmental, safety aspects and addressing the nature of the socioeconomic questions.

Mr. MCDADE. Don't they worry about mine safety?

Dr. LIVERMAN. Yes.

Mr. McDade. What kind of health and safety do you worry about?

Dr. Liverman. All kinds.

Dr. White. Conversion plants, for example. Dr. Liverman has people monitoring our pilot plants.

POLLUTION CONTROL DEVICES

Mr. Murtha. If the gentleman would yield.

I think you have to be more realistic about these pollution control devices and the catchment area and so forth.

Pennsylvania has made tremendous progress, but we right now have a problem in Westmoreland County where we want to open a Volkswagen plant and there cannot be one additional bit of emission into the air. Consequently at this point they cannot open a plant that will hire an additional 5,000 people, and we have an unemployment rate of about 10 percent. So it is not as easy to say the technology is not there.

We don't have anything to close down. And yet that plant is already built and they are preparing to open it at some time in the next couple of years, so it is much more complicated than just saying to pursue actively pollution control devices.

Dr. Liverman. That is correct.

Clearly the pollution that you have, and I don't know that particular area of Pennsylvania——

Mr. Murtha. It is Westmoreland County, which is right next to Cambria County, a lot of steel mills.

Dr. Liverman. We have ongoing programs on board in ERDA that are looking at the question of do you create your own pollution or is some of it moving across the country. It is very clear as you go from St. Louis eastward that some of the sulfates that are emitted, say, in St. Louis, find their way to Altoona and New York City and elsewhere. So we do not yet have the knowledge really to make that pronouncement.

Mr. Fri. But you are encountering essentially a policy problem, not a technical problem.

Mr. Murtha. We are talking about technical problems also because the technology is not available. They have the most modern pollution control devices in the world in this plant going in and they don't have the technical ability to have zero emission. That is what it amounts to. So it is technical as well as policy.

Mr. Fri. Yes, but the policy says you cannot add pollution even with the best available control technology.

Mr. Murtha. I understand that.

Mr. Fri. No matter how successfully we are developing the technology, if you stick to that policy you are in trouble.

Mr. McDade. As the poor fellow who has to look after the environment side of this, what about New York City? Years ago my part of Pennsylvania was shipping I don't know how many tons of coal. Can you sit on that side of the table today and tell us that within 5 or 7 years all those Con Ed plants that are up there can be converted to and burn coal in an environmentally acceptable way?

Dr. Liverman. I cannot tell you that.

Mr. Yates. If you cannot tell him that we will turn it over to Mr. Duncan.

TOLERANCE OF ENVIRONMENTAL STANDARDS

Mr. DUNCAN. I just had one question. In connection with your environmental standards, isn't the problem that we run into is the part of them that says no degradation and isolates that from the health, and safety, and welfare of the people, and when you say no modifications of our standards, don't we have to take a look at that no-degradation standard?

I cannot see how man, who is also part of the environment, can exist and live without having some impact on its environment. What we are trying to do is to eliminate the unreasonable impact, isn't that correct?

Dr. LIVERMAN. Yes, that is my view.

Mr. DUNCAN. I am not blaming you because I think the Congress is largely responsible, but isn't that no degradation and zero tolerance where we run into our difficulties? Zero tolerance gives us problems because in today's technology zero tolerance is OK. Tomorrow we develop a new measuring device and zero tolerance puts everybody out of business.

It seems to me that when we go to these extremes, when we say no degradation under any circumstances, we tie ourselves in a straightjacket of words and ignore the other equally pressing problems.

Mr. FRI. I think you have to realize the Clean Air Act sets forth the following standard, that there shall be no risk of adverse health effects with an adequate margin of safety.

Mr. DUNCAN. How can you do that? It is an impossible standard you set, isn't it?

Mr. FRI. I was Acting Administrator of the Environmental Protection Agency at one time when I announced the city of Los Angeles would have to cut driving by 106 percent in order to be——

Mr. MCKAY. I remember that explosion of almost astronomical proportions.

Mr. YATES. What happened?

Mr. FRI. The Congress is rewriting the law and extending the time schedule for compliance.

Mr. YATES. Is your order still in effect?

Mr. FRI. I don't think it is any longer, no. I did attract attention to the problem.

Dr. LIVERMAN. Let me make one response to Congressman Duncan: I think the important thing we must all keep in mind—the Congress, the people in the street, everybody—is to get all the facts together we can and balance the pros and cons of this situation and not get carried too far away on one side or the other. We have not always been the successful society in achieving that.

Mr. DUNCAN. We will write one of these beautifully worded statutes that says no degradation and zero tolerance, and it sounds good until it gets into the hands of a lawyer who has been put on the Federal bench and construed those words to mean what they say. If it doesn't say reasonable, his hands are tied. I hope you are making suggestions to the committees involved. We will blame you for it. That is part of your job that it, like the wife or the secretary, everything that goes wrong it is their fault.

Mr. YATES. Mr. McDade.

ENVIRONMENT AND ENERGY TRADEOFFS

Mr. McDade. Having been over EPA and gone through the environmental impact statement procedure many, many, many times, I am informed that at no time when the Government with all of its agencies commenting on a proposed EPA regulation, do they hit a question like the one my colleague, Mr. Murtha, raised, that is to say, what are the tradeoffs? If we do find that the air in that part of the country has a level that the law now says is acceptable and therefore we can do nothing, does the Government have to trade that off against the 10 or 15,000 jobs that might be available at the new Volkswagen Co.?

Having been there, do you believe as we get into an era where we are not going to have the clean fuels we wish we did, we ought to change that law as well and require not just the industry that wants to put the plant up but all the Government agencies to comment on the potential loss when they do comment on the potential loss of the 10,000 jobs in Pennsylvania or wherever it might be?

Mr. Fri. I believe a no-risk standard is unreasonable. You ought to look at the costs and benefits.

Mr. McDade. Should the Government be a part of the comment? For example, the Labor Department would never require, I don't believe, if they don't hire those 10,000 people you are going to have 8,000 people unemployed because the unemployment won't go around and the cost will be such and such and the various types of transfer payments we make. Should that be required in your judgment? Answer it for the record if you would like.

Mr. Fri. I think in administering and formulating that sort of legislation you do have to take those kinds of tradeoffs into account whether you write an impact statement, a new standard or whatever.

Mr. McDade. We don't do that now.

Dr. Liverman. I think Congressman Whitten could answer the question but in the insecticide area I believe there is now a requirement that EPA or whoever regulates these, writes an economic impact statement. I think that is the only one in which an economic impact statement is required. We can provide a statement for the record.

Mr. McDade. Please do.

I would appreciate if an amplification of your position, Mr. Fri, could be given on whether we should do that as a Nation.

[The information follows:]

Desirability of Imposing Economic Statements to Evaluate Environmental Standards

Environmental standards should be developed with due regard to economic impacts, and, in practice, the economic consequences of environmental measures have been considered. ERDA believes it is desirable to require Federal agencies to conduct an economic assessment when new standards are being developed. This assessment would provide the basis for the tradeoffs among environmental, social and economic objectives prior to the promulgation of national standards.

The economic impact statements required under Executive Order 11949 currently apply to "major proposals for legislation and for the promulgation of regulations or rules by an executive branch agency."[1] Insofar as the setting of environmental standards involve such major actions by an Executive branch agency, an economic impact statement is now required. Obviously, since Execu-

[1] OMB circular A–107.

tive Order 11949 applies only to new rulings by Federal agencies, it does affect the setting of standards by states nor does it affect the existing body of law and standards already in force.

When addressing environmental impacts on a region in which siting of a non-Federal facility is proposed, economic benefits that the proposed facility may bring to the region should be, and usually are addressed. Consideration of trade-off between environmental impacts and economic and social benefits becomes more crucial if the proposed development is likely to exceed air quality standards in the given region. In such a case, EPA's interpretative rule, (40 C.F.R., part 51), sets forth an emission tradeoff policy that provide for some flexibility in siting a proposed facility that may violate the standards. The EPA emission tradeoff policy allows for some growth if the developer can insure that the proposed facility's emissions will be controlled at the greatest degree possible. The House Clean Air Act Amendments of 1977 has reported out of committee on April 28 endorsed by EPA's interpretative rule.

A broader interpretation of the question would suggest new legislation to impose such analysis for existing standards and to require non-Federal organizations to participate. Such a move has logical appeal, but it would impose an almost unmanageable burden on environmental organizations. Further, it would open the way for extensive litigation on environmental programs probably frustrating the intent of Congress as reflected in existing environmental law.

ALTERNATIVE FUELS DEMONSTRATION PROGRAM

Mr. YATES. The President in his budget message included $300 million for an alternative fuels demonstration program. What is the status of that program?

Mr. FRI. Let me answer briefly and ask Dr. White, whose program it is, to comment on it.

We were basically in the stage of formulating the details of that program when the energy plan came out. We now have to take the energy plan and determine how that program and the energy plan are going to fit together.

Mr. YATES. How does that program differ from the synthetic fuels program which failed to pass the Congress?

Dr. WHITE. The synthetic fuels program was really based on creating a certain amount of capacity for those fuels, having as one of its major features a loan guarantee authority to do so. Following that second turndown by Congress we reappraised our approach and after discussion with a number of staff people, including the staff of this committee, agreed that the more reasonable approach was to consider each project on its own merits and to come in with the idea of building one plant of a commercial demonstration size of each major technology, one high-Btu plant, one oil shale, et cetera, and in each case come to the Congress and ask for the moneys and incentives appropriate for that plant.

We have been in the process of developing the approach of discussing it with various companies, both those who would like to propose a shale plant and companies which have proposed high-Btu plants, how they would respond to a particular proposal. We have met with each of the shale companies and the gasification people. We have talked to the State and local people to be sure that we are considering the environmental and socioeconomic impacts that would be necessary in such legislation so that when we do come to the Congress, we have done so with that sort of preparation. If such a program has merit we would be coming to the Congress during the summer with legislation of that kind.

Mr. YATES. How does it relate to the biomass loan guarantee bill?

Dr. WHITE. That is in the Solar Division and I am not too familiar with the details of that legislation.

Mr. FRI. At one time last year the biomass program was locked up with the synthetic fuels program. They are now proceeding on independent courses.

Mr. MCKAY. Dr. White, you may have already answered my question. I wanted to ask you a question of this synthetic fuels program on the funding. Apparently you said you are moving in an independent fashion rather than by either subsidies or loan guarantees.

Dr. WHITE. We have not come to a decision which we would recommend because this really is based on the analysis of what will come out of the national energy plan and that has not been analyzed.

Mr. MCKAY. This summer you believe.

OIL SHALE COMMERCIAL DEMONSTRATION

Dr. WHITE. Particularly with respect to shale. I am sure that offering OPEC oil prices on shale is going to change that picture. We have to reanalyze this whole thing now.

Mr. YATES. Are you going to build an oil shale demonstration plant, as Senator Haskell wants you to do?

Dr. WHITE. We would hope that we could develop a proposal that makes good sense for a shale demonstration.

Mr. YATES. Are you ready for a demonstration?

Dr. WHITE. Technically we are ready.

Mr. YATES. How much will it cost?

Dr. WHITE. Do we have a price on the shale?

Mr. GUTHRIE. About $110 million.

Mr. YATES. How many barrels?

Mr. GUTHRIE. This would be Government providing 50 percent of the cost of a plant that would produce between 10,000 and 25,000 barrels per day.

Mr. YATES. IGT said if you give it $110 million it could turn out 50,000 barrels.

Dr. WHITE. IGT is not a commercial operation.

Mr. YATES. You don't think they are serious?

Dr. WHITE. I am sure they would consider they are serious, but I don't consider they are qualified to give a good figure on operating it.

MODIFIED IN SITU PROCESS

Mr. MCKAY. Is Occidental ready to go?

Dr. WHITE. Occidental indicates they are ready for their modified in situ. As I understand, their internal thinking is they would not include in that the aboveground retort initially. They have testified, I believe, before Senator Haskell's committee.

Mr. MCKAY. It has raised more questions in my mind than it has solved.

Dr. WHITE. They have responded to an ERDA program opportunity notice for trying their modified in situ method on an advanced variant that is adaptable to the less rich shale. As a result of that, it is in negotiation but we are going to work very closely with them in

their current activities. We have an observer there on what they are doing, and we have access to their proprietary information. I have been told in recent weeks the results of their newest No. 5 retort chamber have been extremely encouraging. We don't have any oil produced yet but it was rubblized very successfully where the one was somewhat less than a perfect rubblization.

Mr. McKay. I have been talking with various technical people. They raised their eyebrows about what we seemed to be getting here about their proposed success. That is why I asked the question—whether we are being sold on a master sheet that we now have professional applicant indicators around here which may not have anything to do with the technology.

Dr. White. It is a very promising technology, there is no question about that.

Mr. McKay. I hope it is successful.

IGT OIL SHALE PROPOSAL

Mr. Yates. I am still not satisfied with your answer. You say here I guess you consider them to be unqualified. We are talking about the IGT program now. "What we are talking about is the usual ERDA procedure to go to a pilot plant."

You have passed that now.

Dr. White. Pilot plants have been run in oil shale.

Mr. Yates. "What we are talking about here is a potential of building based on the PDU we have in Chicago which costs in excess of $1 million, a large pilot plant, and then to go to commercial.

Mr. Yates. What is the advantage of a commercial plant that produces only 50,000 barrels a day? That isn't enough really to satisfy a commercial need, is it?

"Mr. Schora. No; but I think basically it would be marginal and would stand on its feet from an economic standpoint.

"Mr. Yates. Isn't that true with Paraho today? Paraho has a process by which that is done.

"Mr. Schora. That is correct, sir. I think the problem that stands in the way of Paraho is that it is the uncertainty of the future oil prices.

"Mr. Tarman. Also the Paraho demonstration plant does not produce 50,000 barrels a day.

"Mr. McDade. But there is a proposal to try to do that. The Navy is going to run this year 50,000 barrels."

The question that comes to my mind is that it is 5 times what you propose to produce in your plant for the same cost. But what you are saying is IGT can't do it.

Dr. White. There is no way in the world anybody is going to build a 50,000-barrel facility for $110,000,000. It will be 10 times that.

HYDRO RETORTING TECHNOLOGY FOR SHALE

Mr. Guthrie. What IGT is talking about is so-called hydro retorting technology where you are adding hydrogen to the oil shale as you retort it. This requires a hydrogen facility as well as retorting facility. That does pump hydrogen into the shale so you do get an advantage of yield, but I think there must be some error in terms of terminology because there is just no way in the world that you could build—this

will take somewhere around 4,000 to 6,000 cubic feet of shale oil hydrogen uptake. There is no way you can do that with anything approaching this, so I think there must be some difference in what they were intending.

Mr. McDade. You said a magic word that keyed my memory. That was "yield." One of the things they emphasized was much higher yield than any process currently developed.

Mr. Guthrie. Basically they are adding hydrogen to the kerogen in the shale so they lower the gravity which increases the volume. They also then are adding hydrogen to the carbon content on the shale and producing hydrocarbon from that. In effect, this is somewhat analogous to coal liquefaction.

In coal liquefaction you are seeking processes to add hydrogen to coal. The hydrogen retorting technology is attempting to add hydrogen to the carbon that is present in the shale as well as to the kerogen which is present in the shale. That is the source of the increased yield.

Whether or not that is economically a sound way to approach it is a good question and a question worth pursuing. I think it has been taken out of context.

Mr. McDade. I didn't have the impression about the commercial size of it. What attracted me was the higher yield they said was applicable both to aboveground and in-situ processes to western shale and that the startup cost was not much money, like $2.5 million, as I recall the figure. I couldn't understand why, with the possibilities of applying it both places to all the known techniques, apparently it wouldn't be something we would be very much interested in having them do.

Mr. Guthrie. The answer is we are interested and are following up. We have not chosen to fund that in terms of the priority funding. We have chosen to fund the Dow project on gasification and in situ technology in oil shale. This is another technology applicable to both the eastern and the western shales that we do need to consider.

Mr. McDade. Is it reasonable?

Mr. Guthrite. I think it is reasonable to consider but at this point in time we do not have a specific proposal.

Dr. White. I don't think we have a fix on the yield—if you have to generate hydrogen from shale which you would have to out there for coal. If you have the hydrogen you can get more oil out of a ton of shale by that technique by about 20 percent than by normal retorting, but you have to make that hydrogen.

Mr. McDade. Would you take a look at it? We recognize that you had to make some justifications based on priorities for your budget. We don't need to make the same ones. If it looks to you people to be something that is promising, reasonable, please let us know concisely. We would like to get it started.

[The information follows:]

ERDA Assessment of the Oil Shale Proposal

IGT HYDRORETORTING OF THE SHALE OIL

IGT has been performing R. & D. on an oil shale process for a number of years involving retorting in a hydrogen atmosphere. This research has been supported by the American Gas Association. At various times IGT and/or AGA have

proposed Government support for further development of this process. The most recent formal proposal of which we have knowledge is dated August 1975.

The IGT hydroretorting process which has been proposed for processing Devonian oil shales is an aboveground method which requires the mining and crushing of the oil shale and disposal of the spent shale after processing. In the process hydrogen is used to treat the shale converting essentially all of the organic carbon to either gaseous or liquid hydrocarbons. The produced liquid products are fractionated and the higher boiling fractions coked to produce hydrogen to sustain the process.

Technical personnel in ERDA have followed IGT's progress with interest for some years, although remaining unconvinced that a process that requires relatively large amounts of expensive hydrogen could compete economically with more conventional therman retorting processess. In addition, the eastern shales are generally deeply buried unconsolidated glacial deposits that are often located under small parcel private lands making mining the shale difficult and expensive. Disposal of the retorted oil shale rock is also extremely difficult in populated areas of the Eastern United States.

However, IGT proposals have not been rejected on technical grounds. As you know, ERDA's program on oil shale is focused on the development of in situ methods for recovering oil from shale since we believe that in situ technology offers the possibility of lower environmental impact and water requirements.

NAVY OIL SHALE PROGRAM

Mr. YATES. Now let's turn to the Navy. Captain Nelson came into our committee and testified about oil shale.

"Captain NELSON. I located in Colorado, which is intended to set up a plan for developing the shale reserve there—in shale reserve No. 1—should the Congress ask us to do so.

"For example, we hope to do some core drilling to determine where the water is; we would need to do this. We hope to do some drilling in shale reserve No. 1 to determine whether there is any gas supply which could be used to help make the kerogen, which is the shale crude, flow a little easier through pipelines. We hope to locate the depth of the richest beds in this predevelopment plan to where if you were to ask us when and how much will it cost, can you have a shale plant ready to deliver 100,000 barrels of oil per day, we could say we would put our plant right here: here is the shale bed that we would explore and develop to build this plant: here is the supply of our water, and here is how much you would need to develop this oil, here is where we would sell it, here are the pipelines we would plan to deliver it to, and here is how much it would cost to connect to that pipeline with our own line. It would be a complete package that would say what we need.

"Mr. YATES. How much do you need for that package?

"Captain NELSON. About $32 million, sir. That involves a lot of exploration too, environmental work also.

"Mr. YATES. Do you have any idea as to how many barrels you can get out of that? What would full production cost?

"Captain NELSON. A 100,000-barrel-per-day plant, $1 billion just as a guess.

"Mr. YATES. Any estimates as to what that would cost per barrel?

"Captain NELSON. That is 100,000 barrels of oil per day and scattered over the life of that particular reserve, which is about 12 billion barrels. 12½ cents a barrel. That is just writing off the cost of the plant.

"Mr. YATES. That can't be right, can it?

"Captain NELSON. I think so.

"Mr. YATES. Occidental tells us they can produce——

"Captain NELSON. Mind you, I just wrote off the initial cost of the plant, not operating costs.

"Mr. YATES. All right. I am trying to get at what you would be able to sell your oil from oil shale for on the market. Do you have any idea as to that?

"Captain NELSON. I can guess with you on that, Mr. Chairman. I think we are in the order of $14 or $15 a barrel right now actual production costs to get that on the market. It is nearly competitive but not quite.

"Mr. YATES. We had Mr. O'Leary of FEA come in the other day. He predicted within the next 7 or 8 years the cost per barrel of oil fixed by OPEC would probably be close to $22 or $23. At that level you would be competitive."

PACE OF OIL SHALE DEVELOPMENT

What about your plant? Suppose you wanted to produce 100,000 barrels a day. Could that small demonstration plant you are talking about do that for $1 billion?

Dr. WHITE. No.

Mr. YATES. Are we rushing too fast here?

Dr. WHITE. I think we are. I think the best current thinking of the private sector companies who are looking at this, is that the most attractive first step is to build a modified in situ operation which uses the Occidental technique or something similar in one of the leased tracts—mind you, the modified in situ basically takes out about 20 percent of the shale to make the cavity for the rubblization. If you have 50,000 barrels a day capacity, that means 10,000 equivalent share has to come up above ground to be retorted. You need to build a retort—Paraho or Union or one of the proven ones—at the 10,000-barrel-a-day size, which is sort of a modular size.

Later if you wanted to expand surface retorting, you build more side by side. If you started on a modified in situ, you have the above-ground piece and the underground mining would start out with a few chambers and you keep on going and build it up to 40,000 barrels of in situ shale oil a day. In the above ground retort, you would have 50,000 barrels per day capacity, which is considered the minimum commercial size that would be viable. It is just a rule of thumb. Anything below that is just a small demonstration that leads you up to 50,000. A hundred thousand gives you certain economies of scale.

Mr. YATES. What time frame are we talking about? If you are going ahead to build your demonstration plant for the 10,000 barrels per day at a cost of $100 million, how long are you going to take to build that plant, and over what period of time are you going to expend the $100 million?

Dr. WHITE. For that modular retort, if everything went ideally, which it never does, we would be looking at getting approval this year and starting the planning and detailed engineering in fiscal 1978, which would see it built in 1980. That would be about the earliest you could get that on stream, probably 1981 is more realistic.

Mr. YATES. Is it completed in 1981?

Dr. WHITE. I would think so.

Mr. YATES. Are you in production in 1981?

Dr. WHITE. I would think so.

Mr. YATES. Are you asking for that in this budget?

Dr. WHITE. This is what we are talking about coming in on a demonstration level depending a lot on how we analyze the President's energy plan with specific provisions about support of commercial operations. The President indicated he does not want to support commercial first generation existing technology. I don't think that is a problem in shale because there is no existing technology that is commercial today.

Mr. YATES. Are we ingenuous when we put into our report last year, page 43, "The committee urges ERDA to produce a plan which would select one demonstration plant in each of the primary synthetic fuel areas for accelerated development. ERDA should eliminate as many administrative hurdles as possible to move the selected project as quickly as possible."

What you are saying, you are going as fast as any reasonable-minded person should go?

Dr. WHITE. Yes. I think we are moving ahead on shale and have advanced considerably from where we were a year ago. I think we are only a matter of months from negotiating a contract with Occidental which will put us in a major demonstration of that technology.

Mr. MCKAY. A commercial-sized level?

Dr. WHITE. No, a small in situ module. We hope to come in this summer with a commercial level proposal if it is consistent with the President's plan. We need to go over that ground again.

OCCIDENTAL OIL SHALE PROPOSAL

Mr. EVANS. I recall an official of Occidental before this committee and he didn't want Government money or loans. My understanding was all they were looking for, for present current commercial production was a chance to get some better grade ore under Federal leases and let them go; that they are off and running.

Did I hear you say you entered into a noncommercial contract? If so, I am a little confused about where they are.

Dr. WHITE. Subsequent to that testimony or going before Mr. Haskell's committee last fall, a statement of similar nature led us to suspend our negotiations for some weeks while we tried to clarify just what they would do. I believe it was finally brought out and this is in the record, from Mr. Hammer of Occidental and from us, to the effect that in cooperating ERDA would clearly accelerate the commercial application of that technology both through the application of this advanced technique to some of the less favorable shale lands and also the fact that we would in a way be able to vouch for the validity of proprietary technology which Occidental has kept to themselves and which is viewed with some skepticism by other people in the industry.

Participating in this, while we can't publish the proprietary details, if we do confirm it we presume it would make it more credible.

Mr. EVANS. I wouldn't be concerned about the credibility unless it is a matter of raising capital.

Dr. WHITE. I don't think that is the problem.

Mr. EVANS. They said they were ready to go now commercially.

Dr. WHITE. They said this in the Colorado tract where they are dealing with rich shales. They feel the technology which they used

in the original small retort—I believe the one they refer to as No. 3—which is a rather expensive way of doing rubblization—could be commercially viable in that rich shale. It would not be in that less attractive shale lands that are so common out there, but they felt they probably could make a go of it and think they are planning to do this in their joint venture with Ashland.

OIL SHALE PROSPECTS

Mr. YATES. I gathered the impression they were very optimistic about the possibility of extracting oil from shale.

Dr. WHITE. Oh, yes.

Mr. YATES. If that is true, what about the status of the leases that you have or the Department of the Interior has currently which have been suspended? Have they gone into operation yet?

Dr. WHITE. My guess is they will. With this new price situation I think it is almost certain they will be in operation.

Mr. YATES. What price situation?

Dr. WHITE. The proposal of the President that shall oil be allowed to be sold at the price of OPEC oil. If the Congress approves that, that means $13 a barrel instead of $7, which makes all the difference in the world.

Mr. YATES. This is another thing to ask the Secretary. Would you know more than he about the status of the attitude of the companies which have those leases?

Dr. WHITE. I don't believe so. I am sure he is well informed on that.

Mr. YATES. We will ask him.

OIL SHALE RESERVES

Mr. MCDADE. Do you have any idea about the reserves we are talking about?

Dr. WHITE. The reserves are very large, certainly well over 1,000 billion barrels. Some people think near to 2 trillion barrels. How much of that will be recoverable——

Mr. MCDADE. I want to take you to the $13-a-barrel price and ask you the reserves at that level.

Dr. WHITE. A third of it might be a——

Mr. MCDADE. I don't want you to do that. If you need to amplify it in the record, do so.

Dr. WHITE. Quarter to a third maybe.

Mr. MCDADE. Quarter to a third of 1,000 billion?

Dr. WHITE. You get very widely varying figures depending on who you talk to. You might get 500 billion barrels that is available.

There are a lot of reserves. That is why it is so important for us to find out how to get at it. There is going to be a real water problem to get that kind of level. It is no problem with 100,000 barrels a day, but at a couple of million barrels it is. I will provide further data for the record.

SHALE OIL RESERVES ESTIMATES AT $13 PER BARREL

The total known Western oil shale resource based on USGS figures for deposits more than 15 feet thick and averaging at least 15 gallons of oil per ton is 1.82 trillion barrels. Present knowledge of distribution of the oil shale

resource in terms of grade versus depth of burial and other geologic charecteristics that effect applicable recovery technology and economics is not precise. The definition of shale oil reserves at a designated production price depends upon the estimates of the quantity and characteristics of the oil shale resources. The primary variables are the size of the oil shale deposit, the thickness of the seam, the depth at which the seam is located, and the amounts of oil which can be recovered per ton of shale material.

For possible economic recovery by surface processes within the $13 per barrel factor, the best candidates for commercialization would be those resources which are found in relatively thick seams close to the surface, although resources are only converted to reserves at a particular dollar level when a viable economic process is demonstrated. The minimum estimate that has been made for economic recovery by present mining and surface processing technology applied to those richest near-surface deposits is 80 billion barrels of shale oil. This is based on estimated deposits equivalent to 160 billion barrels of in-place oil, averaging 30 to 35 gallons per ton, less than 1,000 feet below the surface, at an arbitrary 50-percent recovery factor.

The availability of in situ methods for recovery of shale oil from some "unmineable" formations is also a factor in the estimate of total reserves. The vertical modified in situ technology is believed capable of processing up to 300-foot thickness of this shale at costs ranging from $8 to $11 per barrel. In situ technologies that address the other, much larger, resource types are presently less advanced, and production costs cannot yet be estimated with any degree of certainty.

PRICE GUARANTEES

Mr. YATES. I am still not sure about the commercial companies that have leases. You think they are going to go ahead. Now that the President has said, and presumably with congressional approval, the companies will be willing to go ahead to develop oil at a price of $13.50 per barrel. Would they also require a guarantee that someone will pay that much for the oil? Suppose, for example, that once they have gone into production the Saudis cut the world price?

Dr. WHITE. My personal guess is that they will request such a guarantee at some level, maybe not at $13, but maybe at $10 or $11.

I don't know. It seems to me, my own personal view again, if we can get the Saudi price down by that technique it would be a pretty good deal.

Mr. YATES. Yes, depending on how long they establish that level.

Dr. WHITE. Drop down, you guarantee the price, and you make money hand over fist compared to what we are doing today.

OTHER OIL SHALE PROJECTS

Mr. YATES. All right. Are we putting all of our eggs in the Oxy basket?

Dr. WHITE. No. We have three other contracts with other techniques.

Mr. YATES. In what state? With Oxy you are going ahead with the demonstration plants.

Dr. WHITE. Two of them are already signed.

Mr. GUTHRIE. No, they are not signed. Equity we think should be signed within a few weeks. All the internal review has been completed.

Mr. MCDADE. What is the name?

Mr. GUTHRIE. Equity. That is a very old family company that has been in the shale oil business for years and their approach is a solution-mining approach where the salts in the shale are dissolved out to give you the fractures for the permeability for the in situ recovery. Geo-

kinetics is another company, and on that one, the target date is June 1. Then with respect to Talley Industries and Occidental, we have a target of about July.

Mr. YATES. Are all those comparable contracts? Are they all for development?

Mr. GUTHRIE. They are all for developing particular techniques. The Geokinetics is a modified horizontal with surface uplift. This is for shale resources that are close to the surface so that you actually will get a little bulge of the surface when you explode to create your fractures.

As I mentioned, Equity creates the void space by solution mining. The Occidental is a vertical modified. This is for deep beds of shale where you create that fracture as a deep retort of 100 to 300 or perhaps even as much as 600 feet depth. The Talley Industries is an instrument in situ approach where you are attempting to fracture with explosives and create the voids directly in place, and all of these are for particular kinds of shale and should be applicable then to a different part of the resource.

ERDA OIL SHALE CONTRACT FUNDING

Mr. YATES. What is the amount of each of the contracts?

Dr. WHITE. We can provide it for the record, but the Oxy one is much the biggest.

Mr. GUTHRIE. Oxy is about $45 milion; and Talley Industries about $10 million; Geokinetics is about $6 million; and the Equity is about $5.5 milion, and in each instance that is the ERDA funding.

Mr. YATES. That is the ERDA funding.

Dr. WHITE. Yes.

OIL SHALE RECOVERABILITY

Mr. YATES. Mr. McKay.

Mr. MCKAY. On the recoverable, your above retort, Paraho, et cetera, what is the recoverability in comparison with that of in situ?

Dr. WHITE. For the in situ and above ground retorting the thought is they wil probably be comparable, in the range of 60 percent perhaps of the total resource. You have to leave the pillars in the room and pillar mine. If you are using modified in situ it is necessary to have walls between these chambers so you can obtain the rubblization and the gas recirculation. The best estimate today with the mining plan as I understand it is maybe 60, maybe optimistically 70 percent.

Mr. MCKAY. In any process you don't expect to get more than 60 to 70 percent at the outside?

Dr. WHITE. I would be surprised if we could. True in situ, theoretically you could do the whole thing. You just drill down and rubblize, but so far it is not very well controlled in the one experiment we have run. We probably won't do very well with it.

Mr. MCKAY. That is one of the problems although some claim you can control it, but anything I have seen says that you are not sure where your fissures are going and you may be in all kinds of trouble.

Dr. WHITE. My own view is that true in situ is not likely to be an attractive way to go. It is a little early to tell. You keep trying it. If we have success maybe we will learn how.

Mr. McKay. You are telling me the mine pillars process, other retorts, surface retorts, are like the coal mines?

Dr. White. For the few places it is strippable which is the case in CA, where you really can take the overburden and take all of that shale down through the dome, then you get all of what you mine. But it is very largely a case of energy stripping of course too.

Mr. Evans. I thought I heard you say that in situ was really going to prove out to be a viable option.

Dr. White. True in situ where you don't do any mining at all.

COAL GASIFICATION

Mr. Yates. Let me turn to coal gasification. Are you cutting down on your support for the program for the HyGas contract in Chicago?

Dr. White. If you read the amount in the budget, the conclusion is we are.

There are two aspects of that and I might say originally we were thinking we would terminate that this year. There is going to be a certain amount of carryover but more importantly we are going out for an A. & E. contract for the conceptual design of commercial HyGas plant with the idea that if it looks attractive, we will possibly consider that as a demonstration plant in addition to, and we would have to have authorization to do this, in addition to the ones that are now being negotiated, the ICGG group and Conoco.

In connection with that design we recognize that there is certain information that is not now available from the previous HyGas work. We have money in the demonstration plant program for design and technical support which will carry the operation of the HyGas plant through as much of the following year as is necessary to get that data.

LIQUEFACTION PILOT PLANTS

Mr. Yates. Your liquefaction program moves up $34 million in 1978, primarily funds for two large pilot plants, the H-coal and the donor solvent. How long will it be before production from plants such as these will be evaluated?

Dr. White. The H-coal plant has just now about 3 or 4 months of actual construction behind it, so it probably has another year to go. The donor solvent design is pretty well done, but it will be certainly late this year before that is started.

So it is 1½–2½ years, I guess, before they will be actually operating and producing products.

Mr. Yates. When will you be able to evaluate the product?

Dr. White. I should explain. We have small amounts of products from bench scale work before, so we know what it is going to look like. The full evaluation will probably take 6 months to 1 year.

SYNTHETIC FUEL ECONOMICS

Mr. Yates. What time frame do you think you will have to have to find out whether they are economically competitive?

Dr. White. I would believe a year's operation of a pilot plant, or 1½ years at the outside would give give us a pretty good fix on the economics.

Mr. YATES. You have projected economies?

Dr. WHITE. Yes. The estimate depends a lot on what assumption you make. This applies, I might say, to any of these fuels that you start talking in dollars per barrel, the form of financing you are going to use and how much contingency you put in, but our guess currently is that when based on $25 per ton coal, and 15 percent discounted cash few, donor solvent would run $30 to $36 a barrel and H-coal maybe a few dollars higher.

Mr. YATES. It is not very competitive at the moment.

Dr. WHITE. Not very competitive, no. SRC II is maybe in about that same range, although we don't have a figure on that here.

George Rial, is that about right, or Martin Neuworth? SRC II is in about the same range?

Dr. NEUWORTH. Yes.

Dr. WHITE. The differences in product quality may be important and perhaps most important is simply operability of those different processes and experience in running those big pilot plants.

Mr. YATES. That indicates that oil shale is a lot cheaper, so that is why you are moving toward oil shale?

Dr. WHITE. Right.

Mr. YATES. If that is true why are you funding oil shale at such a relatively low level by comparison to these experiments?

Dr. WHITE. There has been, of course, a good deal of private sector money in oil shale.

Mr. YATES. Is that the reason?

Dr. WHITE. Tosco and Paraho have been developed without any Government funding at all, where coal has been a very modest amount, really just bench scale.

OIL SHALE FUNDING

Mr. YATES. I think there is enough money in this budget for you to accomplish the goals as quickly as possible. I guess I asked you this before. How much did you ask OMB for oil shale?

Dr. WHITE. Oil shale in situ together, the request to me was $70 million in budget authority and $70 million to OMB, and $39 million——

Mr. YATES. You kind of dropped your voice. $39 million.

Dr. WHITE. $39 million was allowed, out of the $70 million requested.

Mr. YATES. You mean OMB cut you in half?

Dr. WHITE. That is shale and in situ coal gasification altogether.

Mr. YATES. Are you telling me that OMB cut you almost in half?

Mr. GUTHRIE. $28 million for oil shale. That does not include another million dollars——

Mr. YATES. Will you repeat those figures, Mr. Guthrie?

Mr. GUTHRIE. $28 million for operating expense funds, and——

Mr. YATES. That is what you asked of OMB?

Mr. GUTHRIE. That is our allowance.

Mr. YATES. I didn't ask you that. I asked you how much you requested from OMB.

Mr. GREER. $43.7 million.

Mr. YATES. For operating expense?

Mr. GREER. For everything.

Mr. YATES. What did OMB allow?

Mr. GREER. $28.9 million.

Mr. YATES. That doesn't make sense.

Mr. MCDADE. What was the $15 million for if you would kind of capsulize it for us in the record?

Mr. YATES. Well, what was the $48 million for?

Mr. MCDADE. I mean the difference between allowance and what they——

Mr. GUTHRIE. The White Mountain in situ oil shale was dropped.

Mr. MCDADE. With the chairman's permission, unless you wish to itemize them in the record——

Mr. YATES. We can get it in the record but how much of the $29 million is operating expenses?

Mr. GUTHRIE. $28 million is for operating expenses and $1 million is for capital equipment.

Mr. YATES. Do you need more than $1 million capital?

Mr. Guthrie shakes his head no, and Dr. White shakes his head no.

And the $29 million is adequate for your purpose. You are squirming, Mr. Guthrie, but that doesn't tell us anything.

Mr. GREER. We can get you a better analysis. I think the difference was the division proposed to do another set of proposals in shale and OMB felt that was a lesser priority.

FUNDS NECESSARY FOR OIL SHALE

Mr. YATES. As one member of the committee I am impressed that you ought to move ahead in oil shale, and the question I would like you to answer is whether or not you are funded adequately to move ahead as quickly as possible in the field.

Dr. WHITE. No, I think I would have to say that we could move faster——

Mr. YATES. How much money do you need to move faster? What do you need?

Do you want to think about it overnight?

Dr. WHITE. I think we would. The original one is not really quite the answer.

Mr. YATES. Why don't you think about it overnight and let us know what the answer to this is? The President has indicated in four appearances last week that we have a very critical situation. The testimony before us today is that oil shale offers the most promising means to obtain oil from the quantities we want from the raw energy inventory we have on hand? If that is true, doesn't it make sense to proceed with that as quickly as we can, or does it not? What do you think, Mr. Fri? You are the policymaker here.

OIL SHALE FUNDING ANALYSIS

The budget request of $42,550,000 in fiscal year 1978 is an amount considered necessary to carry out the goals and objectives of the oil shale subprogram. Oil shale is a very active, viable area of research by industry and Government designed to bring this resource into commercialization by 1980. The OMB allowance would result in a very constrained effort in oil shale as follows:

BUDGET AUTHORITY

[In thousands of dollars]

	Request fiscal year 1978	OMB allowance fiscal year 1978
Operating expenses:		
Shale oil production	33,105	21,055
Shale gas production	4,450	3,850
Environmental	1,380	1,380
Supporting research	3,615	1,715
Total oil shale	42,550	28,000

The impact at the technology level is as follows:

SHALE OIL PRODUCTION

The ERDA oil shale subprogram is focused mainly on developing technology capable of improving total resource recovery and lowering environmental impacts and water requirements. This is accomplished through development of various in situ extraction techniques capable of exploiting the leaner and deeper oil shale deposits as well as offering an improvement to present aboveground technology. Work has progressed to the point where contract negotiations have begun with four successful respondents to ERDA's PON No. 2 for various in situ technologies. This budget cut will retard the progress of this work for 2 to 3 years because of decreased levels of effort. Additionally, the development of a scenario to handle the potential environmental and water impacts will be delayed because of a dearth of information in the area of process technology.

In private sector, R. & D. on second generation aboveground retort technologies has not begun because the first generation designs have not been tested under commercial conditions. Effective utilization of the resource in the long term will require second generation surface technologies. Considering the long lead times inherent in this type of research it is vital we begin now.

Fiscal year 1978 is the beginning of an intensive effort at finalizing the techniques to be used in the first 20–30 years of oil shale resource development. This effort will take 5–8 years and is capital intensive in the first 3–4 years. Delays in the program at this time required to meet the OMB allowance level will cause severe real time delays in resource utilization. The industrial and governmental participants in these proposed projects will have to cut back their effort for now and it will take 1 to 2 years to return to this state of preparedness in addition to the delays caused by project cancellation. Industry and Government research establishments are poised and ready, their efforts are coordinated and any delay will be compounded because this state of readiness cannot be maintained for very long with no progress.

SHALE GAS PRODUCTION

A major contract in this technology is an eastern gasification project on Antrim shale. The fiscal year 1978 OMB reduction will cause a delay of at least 6 months in this contract.

SUPPORTING RESEARCH

The project is directly related to the shale oil production project. The monies are necessary to conduct indepth product and resource evaluations in relation to the variations in process technologies. This will aid in improving the process to give higher yields of desired products and lessen the possible environmental and water impacts of the technologies. The evaluations conducted on the PON No. 2 in situ technologies and the shale gasification project will be the basis for planning the second generation in situ technologies which will be necessary for optimal utilization of the resource in the long term. If the shale oil production projects proceed as planned much of their long term impact will be delayed until the necessary supporting research is completed. If shale is to make a significant contribution to the Nation's energy goals for the mid- and far-term this research is necessary today.

Mr. FRI. I think it makes a lot of sense to proceed with oil shale. One thing that must not be overlooked is that in addition to the $29 million in this program, part of the $300 million for the alternative fuels demonstration program could be slated for oil shale demonstration.

Mr. YATES. $300 million? I am sorry, I didn't hear that.

Mr. FRI. There is a line item in our budget called alternative fuels demonstration program a $300 million item. One of the two projects that we had thought about proposing in that——

Mr. YATES. But you haven't proposed yet?

Mr. FRI. That is correct. We are reviewing the legislative proposal against the provisions of the National Energy Plan.

Mr. YATES. Then do you want to leave that for a supplemental appropriation? Is that what you are suggesting?

Mr. FRI. We propose appropriations for this program with the thought that we would bring up the specific project to the Congress for authorization and approval before we march off with any project.

Mr. YATES. Do you not have authorization now? What would the authorization be for?

Mr. FRI. The authorization would for basic authority to conduct such projects and for an appropriation of $300 million against which to submit specific projects for individual authorization. This goes back to that synthetic fuels program we had last year.

Mr. YATES. What is your present authorization in the field of oil shale? Do you have any limitation on the amount you can spend for it?

Mr. GREER. We have asked for the $29 million, in our fiscal year 1978 request.

Mr. YATES. You have asked for authorization.

Mr. GREER. Authorization of the $29 million as part of our fossil energy development program. We have also told the authorization committees about our plans for the alternative fuels demonstration program, and said we will send up a legislative proposal later in the fiscal year for specific project authorization once we have determined what the parameters are and so forth.

Mr. YATES. Then it is going to be a supplemental.

Mr. GREER. It might have to be both supplemental authorization and appropriation.

Mr. YATES. Is that true of your entire synthetic fuels program?

Mr. GREER. Yes, sir. There is no legislation before the authorizing committee today for the alternative fuels demonstration program. Unless they added it themselves it would have to be supplemental authorization and supplemental appropriations.

Mr. YATES. The ERDA bill that was in conference was never finally enacted?

Mr. GREER. The status of 1977 authorization is as follows. The Senate has passed a nonnuclear bill and a piece of the nuclear portion. The House last week reported out of the full committee a total bill, both nonnuclear and nuclear portions, but it is a different version than the Senate's so there may have to be a conference on the 1977 bill.

OTHER ERDA FUNDING PROPOSALS NOT REQUESTED OF CONGRESS

Mr. McDade. Apart from the subject of oil shale, which it now appears is not really an OMB problem, it is a problem of authorization, I would be very, very grateful if the people in your organization would look at the initiatives that you are asking the Congress to appropriate money for and let us know if there are any reasonable opportunities that have been denied by the OMB that appear to you to be reasonable investments in trying to get through this energy problem. I would like to know if there are, what they cost, what you intend to do, what the potential payout is, and you can do that at your convenience in the record.

Mr. Fri. Very well.

[The information follows:]

STATUS OF LEGISLATIVE PROPOSAL FOR ALTERNATE FUELS DEMONSTRATION PROGRAM

Pricing and other policy initiatives included in the national energy plan of April 29, 1977, should provide a significant step in encouraging private enterprise to go forward in synthetic fuels projects. The plan states that, "In general, the Government seeks to avoid subsidization of existing technologies, although circumstances may sometimes merit an exception to that policy." Since exception may arise it is desirable to have available, in addition to the authorities provided to ERDA in section 7 of Public Law 93-577, generic loan guarantee authority and contingency funds. In this regard the 1978 budget now contains $300 million BA under proposed legislation to cover projects that might be submitted to demonstrate synthetic fuel plants at commercial scale.

Under the national energy plan, this $300 million will be retained in the President's 1978 budget, but considered in the nature of a contingency. We do not intend to seek authorization of any projects at this time. We will reexamine the necessity for carrying a contingency of this nature beyond 1978 in the development of the 1979 budget.

The Senate has now passed a bill (S.37) which would provide generic loan guarantee authority for ERDA. That bill is now being considered by the House Science and Technology Committee. The Administration supports such generic loan guarantee authority.

At this time, however we do not support further specific authorities to the generic authority such as loan guarantees for biomass plants. We think it more appropriate to make use of the generic authority on a project-by-project basis rather than on a designated program basis.

FURTHER FOSSIL ENERGY PROPOSALS

Mr. Yates. I think you ought to consider this too: The possibility of being funded subject to authorization, and I think that in order to save time if in fact there are oil shale projects, or other projects, for that matter, that you think ought to go ahead on the assumption that they will be authorized and proof also placed before our committee, the committee would be glad to consider that, and that is why I suggested to Dr. White—you are going to be here for 3 days—that perhaps rather than waiting for summertime to present your program—where is it? You don't have it prepared?

Dr. White. No; I would not presume to present that as an individual project yet. We really haven't got our work done on that.

Mr. Yates. All right. There is no way the committee can help you with that now, is there?

Dr. White. I think to keep the appropriation request of $300 million intact certainly keeps a hedge. That really gives us an option to

progress on a later project-by-project approval. However, the program is being reexamined in light of the National Energy Policy announced by the President.

Mr. YATES. What options does that give you with respect to oil shale?

Dr. WHITE. One of the proposed plants that I mentioned was——

Mr. YATES. That is included in the $300 million.

Dr. WHITE. Included in the $300 million was the possibility of going full blast on a commercial-sized plant. Now, the question is whom we would do that with, for example, Occidental has indicated they are not interested in doing that on a commercial level. If they were clearly going ahead commercially in their present plans, especially with the new prices, I think we would drop the oil shale proposal other than just for demonstrating one of the retorts on a smaller scale. The multimineral one is another one like that.

Mr. YATES. Has OMB hurt you in any respect?

Dr. WHITE. OMB traditionally cuts. Like any research organization, I suppose we know we are going to get cut and intend to ask for a little more than we—

ACCELERATING THE OIL SHALE EFFORTS

Mr. YATES. Are you hurt by the amount that came out of OMB?

Dr. WHITE. I think in shale we are. I did find what we said on the oil shale program still valid today.

Fiscal year 1978 is the beginning of an intensive effort at finalizing the techniques to be used in the first 20 to 30 years of oil shale resource development. This effort will take 5 to 8 years and is capital intensive in the first 3 to 4 years. Delays in the program at this time will cause several time delays in resource utilization. The industrial and governmental participants in these proposed projects will have to cut back their effort for now and it will take 1 to 2 years to return to this state of preparedness in addition to the delays caused by project cancellation.

The stretching of the initial work in the capital intensive part of the first year or two I think will cause delays, and that is why I would like to sit down with Mr. Guthrie——

Mr. YATES. How much money is involved?

Dr. WHITE. I am not sure because there is this fifth type of retorting that I would want to look at pretty carefully before suggesting we go to that one. If you have four of them, the marginal value of this fifth one gets pretty questionable.

Mr. YATES. Did you ask OMB for the fifth one?

Dr. WHITE. Yes, sir.

Mr. YATES. But you didn't look at it carefully before you submitted it?

Dr. WHITE. It seemed worthwhile, and I think it still is. If we are going to compromise I would much rather drop that one out and speed up the others than to keep the others slow and add a fifth one.

OCCIDENTAL'S OIL SHALE PROPOSAL

Mr. GREER. One important change. The Occidental statement to the effect they could do it without Government money was just a few weeks old when we went through the review of the February revision

with OMB. The OMB view could have been that there was a great deal of money available if the Oxy proposal was to go it alone. So I think that was one of the factors.

Mr. YATES. Is there any change in that Oxy proposal?

Dr. WHITE. Now it is in for funding, $45 million identified against that proposal.

Mr. YATES. How much will Oxy put in?

Dr. WHITE. Equal amount in total, 50–50.

Mr. YATES. Will you get a 50–50 share?

Dr. WHITE. Yes.

MAGNETOHYDRODYNAMICS AND OTHER LONG TERM TECHNOLOGIES

Mr. YATES. While I have you on OMB, has OMB hurt you with respect to any of your programs other than oil shale?

Dr. WHITE. MHD is not a great favorite of OMB's.

Mr. YATES. As I undedstand it, it was not a great favorite of yours either.

Dr. WHITE. I supported completely the request for $86 million that went to OMB.

Mr. YATES. For 1978?

Dr. WHITE. For 1978.

Mr. YATES. But in 1977 you weren't that enthusiastic for it?

Dr. WHITE. No, but I see the program slipping pretty severely if we don't start funding this. Certainly we will not be able to fulfill the commitment that authorized this component development and integration facility in Montana at the pace we are currently setting if we are not funded at a higher level than we are now. I think we had a little lack of communication on that the year before.

Mr. MCKAY. Doesn't that beg the question? You are not very excited about MHD, period, is that right?

Dr. WHITE. No. Let me switch positions, my thinking has changed that.

Mr. MCKAY. We want to get that plant started.

Dr. WHITE. May I raise a point?

Mr. YATES. Sure.

Dr. WHITE. My thinking has advanced a little bit in this area, in not only MHD but a couple of others. We passed legislation for the best available techniques to protect the environment and it seems to me that maybe we, and I refer to both the Administration and Congress, consider the possibility of applying the best available techniques to efficiently use our resources when we are converting to electric power. MHD is one such potential system if you are generating electricity from coal. Another is the molten carbonate fuel cell, which is about as efficient and cost effective as MHD. The third one is combined cycle, and all these are long-term technologies that is, they will not be available for commercialization until after 1989. None of them is ready today not even for a pilot approval. But they have the potential of substantially increasing the efficiency of the amount of electricity we get from a given amount of coal.

It seems to me, given the urgency of our long-range situation, perhaps we better move all of these ahead just about as fast as we can.

Mr. MCKAY. Which is a change in your attitude?

Dr. WHITE. Yes, it is. I hadn't thought of it in those terms. They aren't going to answer the problem in 1985 but in terms of our long-range outlook, I think they do represent something important to us in our resource utilization.

Mr. YATES. What is your time schedule for MHD?

Dr. WHITE. We are building the CDIF now and I believe it is going onstream in fiscal year 1979. This is really a small experimental MHD plant.

Mr. YATES. Is this in Montana?

Dr. WHITE. Yes; the big engineering test facility which will follow will be about 200 megawatts and will be the final step before commercialization. We really have to wait on the operation of the CDIF to finalize its design. So that is probably ready to operate in 1985.

Mr. YATES. Is the ETF a pilot plant?

Dr. WHITE. Essentially it is.

ENHANCED RECOVERY OF OIL AND GAS

Mr. MCDADE. We talked about tertiary enhanced methods on recovery as a very attractive alternative even in the short term. Where does that one sit now?

Dr. WHITE. That is going full blast. There is your reverse case. We actually have more money than was asked for. The reason is that when we first formulated the budget it was before we had completed our national recovery management plan. When we discussed that with OMB we recognized there were occasions where it was obvious that more money could be very cost effective in bringing forward some of the more promising technologies. We still have less than we originally presented in that plan for 1978 but it is up toward that.

Mr. MCDADE. How much of a cut was it?

Dr. WHITE. As I recall, what we originally asked OMB was $40 million for enhanced oil recovery and the revised budget to Congress requests $46 million. I think the plan would have called for about $57 million. The reason we picked that, we do a curve of projects, which is the potential recovery and there is sort of a bendover in that curve. If you go beyond that bend, the amount you get for additional money begins to fall off a little.

To further answer your question, one of the things we are very encouraged about, some of these tests are showing enhanced oil recovery.

Mr. MCDADE. By what kind of percentage?

Mr. GUTHRIE. Yes; I think what you are really looking at now is a curve that should have been declining and it has passed through the inflection point and is actually increasing; it is not a blip in the curve. A lot of thing can change production. For example, at the Phillips test they now estimate they are roughly double the production they would have been without the tertiary project. They estimate now as things continue they will eventually reach about four times the production level they would have had without this.

Mr. MCDADE. Is that just an isolated field?

Mr. GUTHRIE. It is an isolated test. This is the north Burbank field in Oklahoma. They have taken one test area for this.

Mr. McDade. What is the technique?

Mr. Guthrie. This is where you put a detergent down and follow that up with a polymer water-driving solution.

Mr. McDade. It has increased the production of the field four-fold.

Mr. Guthrie. That is their present estimate based on where they are on the curve and they are double the production now.

Mr. McDade. Shouldn't we be going full tilt here?

Dr. White. We have some 30 projects in oil and gas in different parts of the country.

Mr. McDade. You are not ready to say one is the technology?

Mr. Guthrie. Almost certainly there will not be just one technology. We are working on three technologies. Miscellan polymer, carbon dioxide, and heat, but some are using sandstone with heavy oil, some with limestone—different types of geological formations and different techniques give that combination.

ENHANCED RECOVERY ECONOMICS

Mr. McDade. This was always terribly attractive to me because we used to speak of it as a near term in the 5- or 7-year solution. Are we still in that ball park?

Dr. White. Yes. I think it very likely that with the exemption of tertiary oil from controls as proposed in the President's energy plan, we may stop doing any more funding. We can't tell yet but this may be so attractive it goes by itself.

Mr. McDade. At $13?

Dr. White. Yes.

Mr. McDade. We added $10 million in the congressional legislation, didn't we?

Mr. Guthrie. The chemical flooding methods are expensive and it can run $4 to $10 a barrel for the chemicals, so having oil at a world price is an important consideration for chemical flooding methods.

Mr. McDade. I wanted to pursue this. Can you flush this out a little for me? This is one I know we always had trouble with OMB on, and we constantly broke the budget of this committee because of the testimony about potential of what they might be able to accomplish. We have one that you have mentioned, a very significant increase. Are there others using the other two technologies?

KEWANEE ENHANCED OIL RECOVERY

Mr. Guthrie. We have a project with Kewanee Oil Co. which actually has passed the inflection point on the curve and that is a waterflood where you have added a chemical.

Mr. McDade. What do you mean by inflection?

Mr. Guthrie. You have a curve and the decline curve in production in the field is 6-percent decline and it has reversed and gone upward and at this point the Kewanee production isn't that significant in relative production but it definitely has passed the inflection point.

Then we have an in-house project also, which has just passed the inflection point. These are all within the last month.

TIMING OF EOR PROJECT

Mr. McDade. If I were to ask the question, how long is it going to take to prove whether they are thoroughly effective methods, what would your answer be?

Mr. Guthrie. I think, for example in the Phillips test we would not expect them to reach full production for at least 4 years. This solution is moving at about a foot a day in that range so it is slow to find the results.

Mr. McDade. What about the other two?

Mr. Guthrie. I think the other two—I think Kewanee will begin to have something of a production increase within the next couple months.

Mr. McDade. Is there a way to estimate the potential addition to the pool?

Mr. Guthrie. You have differing kinds of charcoal flooding methods applied to different kinds of reservoirs. There are also tests which have failed, we know, in industry, and we have some tests which are not yet successful here, so we really are working on a time frame with industry to try to determine when the constraints are to bring our help where we see a constraint.

We have a major project with Marathon in Illinois which will probably be at least 2 years before we know, but if we have continuing successful results then I think you will have industry moving in to take over these technologies.

POTENTIAL OF ENHANCED OIL RECOVERY

Mr. McDade. But the bottom line for me is when I go home, "Mr. Congressman, what are you doing with that for the $7 million you have been giving to ERDA for tertiary recovery?"

I am trying to ask you——

Mr. Guthrie. You see estimates that range from 60 billion barrels to a high of 100 billion barrels of oil from the various enhanced recovery techniques. These are estimates assuming the technology is applied.

Mr. McDade. What kind of prices follow those estimates? Low price, high price?

Mr. Guthrie. We have determined if you increase the price of oil to $20 a barrel for example, in the absence of accelerating research, you would probably double the enhanced oil recovery from about 600,000 barrels a day to a little over 1 million. If you can in fact implement research technology to improve these various techniques, we estimate that the research effect will build you up to about 3 million barrels a day. In other words, in our judgment prices above the landed world price of crude oil will not be as great a stimulus as overcoming research constraint. That is an opinion that not everyone shares but it is a considered opinion on our part.

Mr. McDade. Thank you.

SOLVENT REFINED COAL

Mr. Yates. You are going to propose another amendment to the budget, as I understand it, to begin design of a solid product solvent-refined coal demonstration plant.

Mr. Fri. That is correct.

Mr. YATES. What is the market for the product?

Dr. WHITE. The SRC market would be the utilities. They wish to avoid either the installation of scrubbers or the installation of a coal gasification facility to serve their particular utility. It gives them independence because they can buy the coal, have it delivered and piled at their utility and feed it just like they could oil on site.

Mr. YATES. With what processes will this compete?

Mr. GUTHRIE. A fluidized bed is likely to be a major factor in the utility industry.

Mr. YATES. Is this going to be on a 50–50 basis?

Dr. WHITE. We haven't really developed that.

Mr. MCKAY. Is this aimed at using Eastern coal rather than Western coal?

Dr. WHITE. Yes. Your Western coal is already low-sulfur. It is primarily Eastern coal. That is what we have tested at the Tacoma, Wash. plant, Eastern coal.

Mr. YATES. Will this be under competitive bidding?

Dr. WHITE. Presumably. We haven't really looked at that. There are at least two firms in industry in SRC who have some technology.

Mr. YATES. This is being investigated in foreign countries as well.

Dr. WHITE. Yes. As a matter of fact, the Gulf oil process was developed with Bureau of Mines support patents, owned by the Government, with the proviso that Gulf has the right for foreign technology. I believe they are interested in trade with Japan.

Mr. YATES. Is it being financed by the U.S. Government in foreign cases?

Dr. WHITE. No.

Mr. YATES. How about the foreign governments; are they financing their own?

Dr. WHITE. I don't think we know.

FUNDING OF DEMONSTRATION PROJECTS

Mr. YATES. You speak of demonstrations as being a step immediately prior to commercialization. Is there an industrial commitment until the design of the plant is complete, which is a process that takes several years and is fully funded by the Government?

Dr. WHITE. Certainly the demonstration plants that we have negotiated thus far have been on the basis that the original design phase is 100-percent-Government funding.

Mr. YATES. Why doesn't industry contribute to that?

Dr. WHITE. We didn't ask them to. We are not going to do that again. We plan to ask them to contribute to the design phase. I think that is going to insure a more serious and certain commitment to proceed.

Mr. YATES. When are you going to start changing?

Dr. WHITE. As far as I am concerned the next one we go out on is going to be that way.

COAL LIQUID REFINING FACILITY

Mr. YATES. Why do you need a coal liquid refining facility? Doesn't the industry have the capability of producing small quantities?

Dr. WHITE. No. We carefully surveyed the industry and they did not. They have some capability but we have asked them to bid on what they would need to do to enlarge that capability, not building something from scratch if they had some facilities that were available. I don't know that we have the results of that in yet.

Dr. NEUWORTH. We made a survey. That is still coming in.

Dr. WHITE. We don't know just what we will get on that.

Mr. YATES. Why is the cost $50 million?

Dr. WHITE. That is a guess of what will be bid on. We don't know but if they have to build very much even at the small capacity—after all, a pilot plant costs us twice that.

THE CRESAP FACILITY

Mr. YATES. You want $12.5 million for Cresap. Is that just to operate the facilities?

Dr. WHITE. Yes.

Mr. YATES. What are you going to do there in 1977 and 1978?

Dr. WHITE. I think Dr. Neuworth can answer that question.

Dr. NEUWORTH. We are planning to test the steps in coal liquefaction configuration. Our principal concern is for solids and liquids. When you dissolve all the coal, the mineral matter remains to be separated and that is one of the key steps in liquefaction. We have an improved version of doing that at Cresap which we will be able to test.

Mr. YATES. How far will you go in 1977 and 1978? Will you be through testing?

Dr. NEUWORTH. Our present program will be.

Mr. YATES. That seems to go on and on.

Dr. WHITE. It really is a test facility. It will go on and on if it is worth anything. We may be testing coal feeding.

COALCON PROCESS

Mr. YATES. On page 22 you indicate you want reprograming of $10 million for small-scale testing of the Coalcon process. Do you intend to go ahead with that?

Dr. WHITE. This still has promise but it has to be tested on a small scale to get some data on the liquid yield and the quality of liquids available from the original development.

Mr. YATES. That is $5 million less than the amount available for obligation in 1977.

Dr. WHITE. This really fell out of a change in that whole program plan.

Mr. YATES. I think we will stop here and come in at 10 o'clock tomorrow morning.

TUESDAY, APRIL 26, 1977.

WITNESSES

ROBERT W. FRI, ACTING ADMINISTRATOR
DR. GENE G. MANNELLA, ACTING ASSISTANT ADMINISTRATOR FOR CONSERVATION

DR. PHILIP C. WHITE, ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY
DR. JAMES L. LIVERMAN, ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY
DENNIS R. SPURGEON, ACTING ASSISTANT DIRECTOR FOR REPROCESSING, DIVISION OF WASTE MANAGEMENT, PRODUCTION AND REPROCESSING
M. C. GREER, CONTROLLER

BUREAU OF MINES ACTIVITY IN OIL SHALE AND NEED FOR COORDINATION WITH ERDA

Mr. YATES. Let's call the meeting to order.

Dr. White, I have a press release from the Department of the Interior, and I know your blood gets chilled every time I open the question that way, entitled "Costs and Methods For Large-Scale Oil Shale Development Detailed In Bureau of Mines Reports." It says:

> Six potential approaches to developing deep, thick oil shale deposits in Northwestern Colorado are detailed, along with cost estimates for each, in two reports just placed on open file by the Interior Department . . .

Then it talks about the mining of the oil shale. These are Bureau of Mines activities. But then it goes along and talks about a report by Fenix and Scisson done under a $370,000 contract:

> . . . begins with preliminary evaluations of the four methods of producing shale oil by a combination of underground mining and in situ processing. Two methods were then chosen for detailed analysis as the most promising for gaining access to processing areas, where drilling and blasting operations would produce subterranean "chimneys" of rubbelized shale, ready for retorting.

Then they talk about the shape of the chimneys and drill hole patterns.

Then they have another report by Woodward-Clyde Consultants, which deals with a related problem of oil shale production and disposal of spent shale.

Isn't this kind of poaching on your territory?

Dr. WHITE. It certainly has that sound to it.

Mr. YATES. I am sure you read it.

Dr. WHITE. I have not seen this particular press release.

Mr. YATES. But yesterday we were told you were cooperating with the Bureau of Mines' or somebody said that as I recall, that you have a fine coordinating committee with the Bureau of Mines.

Dr. WHITE. We are, I would have to say, in the process of developing what I think will eventually be effective coordination. I cannot say that we are fully there today.

Mr. YATES. All right. It is $99\frac{44}{100}$ percent up to now.

Dr. WHITE. Well, close. I think we are in the right direction. We have had meetings with them. We have another meeting scheduled I think it is the end of this coming week.

Mr. YATES. As I understand it, you are in charge of oil shale production. I mean ERDA.

Dr. WHITE. In terms of producing the oil from shale, yes. In terms of mining research that might lead to an improved underground mining technique, that really is their side of it.

Mr. YATES. All right.

Dr. WHITE. In situ would certainly be ours.

Mr. YATES. We want to keep them in their own basket.

Mr. WATKINS. We are aware that the Bureau of Mines does have the mining program in oil shale.

Mr. YATES. I can see where each of you would have a function to perform. These are letting contracts for oil shale retorting.

UTILIZATION OF ADDITIONAL FUNDING FOR OIL SHALE DEVELOPMENT

Yesterday I asked you about the amount of money that you would need for oil shale development and you promised that you might let the committee know what the amount of money was that you needed so that we might be helpful.

You told us it was what you asked OMB for.

Dr. WHITE. We have restudied the general picture of the program and how it has evolved.

Mr. YATES. You mean yesterday.

Dr. WHITE. After our meeting yesterday.

Mr. YATES. With a great deal of soul searching you came to a certain conclusion?

Dr. WHITE. We see no reason to change our original position of the amount of money needed to move the program at an optimum pace.

Mr. YATES. The amount of money you asked whom? The Director for, or the OMB for, or what?

Dr. WHITE. The amount of money that was originally requested of OMB——

Mr. YATES. Which was how much?

Dr. WHITE. It was $43 million. As we pointed out, this would be, we considered, an optimum pace, and if choices have to be made, obviously, like many places this one would have to yield too.

Mr. YATES. This is an optimum pace, $43 million.

Dr. WHITE. Yes; and I think that clearly, as in many other programs, if we have less money we have to slow down.

Mr. YATES. You are telling us there is no occasion to expand your plan beyond those that you drafted for submission to OMB? The optimism that you displayed yesterday before the committee was just as great yesterday as it was when you gave it to OMB?

Dr. WHITE. Yes.

Mr. YATES. No greater, no less?

Dr. WHITE. Yes, sir.

Mr. MCKAY. This is on oil shale development?

Dr. WHITE. Oil shale development as a total category.

Mr. MCKAY. All that does is keep it at the existing authorized level. You don't really make any surge in it, do you?

Dr. WHITE. Mr. McKay, I might point out that the 1977 figure for oil shale is $22 million, and $43 million is what we requested, which is quite a surge.

EFFORTS TOWARD COMMERCIAL-SIZE OIL SHALE PROJECTS

Mr. MCKAY. But that may not be enough to do much for a long time. We have a lot of things that we, through the Congress, keep

going by some studies and spread out the studies some way. All we do is keep them alive and they don't go anywhere. You think this money would push it ahead in its total development toward a commercial size plant?

Dr. WHITE. Yes; although this particular amount of money does not in itself have a commercial size plant in it.

Mr. MCKAY. Given that amount of money, how long would you project in that research attitude or mode will it take to get a commercial size plant?

Dr. WHITE. In this mode I think we would have the technical development that would put us in readiness to design a commercial plant within 4 years.

Mr. MCKAY. So you are looking at how many years?

Dr. WHITE. About 4 years.

Mr. MCKAY. How long will it take you to construct a plant?

Dr. WHITE. Probably an additional three.

Mr. MCKAY. So we are looking at 6 to 10 years as a minimum under this mode before you could possibly get a plant constructed even if research gets going?

Dr. WHITE. I might recap what we talked about yesterday. One of the possible initiatives that we originally examined was a module of a commercial plant as part of the proposed Alternative Fuel Demonstration Program. This would not be based on ERDA's in-situ research but would be built primarily using the available knowledge in industry today and at the $300 mililon we talked about for the alternative fuels in additional amount would partly go for that, which would encompress that timetable very significantly.

[Note: Subsequent to the hearing, ERDA provided the following statement on the status of the legislative proposal for the alternate fuels demonstration program. The statement follows:]

Under the Energy Plan, this $300 million will be retained in the President's 1978 budget, but considered in the nature of a contingency. We do not intend to seek authorization of any projects at this time. We will reexamine the necessity for carrying a contingency of this nature beyond 1978 in the development of the 1979 budget.

Mr. MCKAY. You don't see any retort process then coming on other than in-situ.

Dr. WHITE. Well, our position has been right along that the above ground retorting work is ready now to design, with reasonable risk, a module of a commercial plant, with a daily capacity of 6,000 to 10,000 barrels.

Mr. YATES. You really moved your position. You were in favor of the surface retorting really before you moved to in-situ as I remember.

Dr. WHITE. We felt there wasn't much need for further work by ERDA on it because it had been demonstrated by Tosco, Paraho——

Mr. YATES. And all that was necessary was for the price of oil to rise?

Dr. WHITE. Some way to make it economically attractive.

Mr. MCKAY. But what you are telling me with the present mode of appropriations, the $42 million you requested or $43 million, that before you could get the design it would be 3 years at a minimum?

Dr. WHITE. I want to make it very clear that I was interpreting your question as specifically referring to this funded research on the in-situ work, that it would not be far along this soon. Now, obviously, based on Occidental's testimony in several hearings, they feel that one aspect of their technology is ready now.

Mr. MCKAY. One aspect. You can get one aspect of any research operation completed, but that doesn't take you anywhere without another step.

Dr. WHITE. They are ready to go commercial with their technology. They can be commercial they say within 3 years.

Mr. MCKAY. And you have $45 million, and they will be ready to go commercial in how long?

Dr. WHITE. They are ready to go commercial, they say, in their particular way of operating on enriched shale right now, they say.

Mr. YATES. Are you going to give them the land to do it?

Dr. WHITE. They have the land. They entered into an agreement with Ashland——

Mr. YATES. I see.

Dr. WHITE [continuing]. In the Colorado B tract.

Mr. YATES. I remember when they testified that the shale they were working on wasn't the rich shale.

Dr. WHITE. No; that is right.

Mr. MCKAY. So you expect them on line with a commercial plant when?

Dr. WHITE. I have no reason to question their present plan, which I believe is about 2½ to 3 years.

Mr. MCKAY. So we will have a commercial sized oil shale in-situ plant on line. We will have to give them 1 year's leeway. They never come through with those first projections.

Dr. WHITE. I stand corrected about that. They say 4 years.

Mr. YATES. In 4 years then they are going to turn out how many barrels of oil a day?

Dr. WHITE. I think that originally the plan was 50,000 barrels per day.

SUPPLY AND DEMAND

Mr. YATES. Dr. Schlesinger was supposed to meet with us today and unfortunately he had to cancel. Can I use you, Mr. Fri, as Dr. Schlesinger for a moment?

Mr. FRI. I don't know how happy he would be. I am happy to try.

Mr. YATES. All right. Try Mr. Fri.

I turn to an article in Harper's Magazine dated May 1977 entitled "More Heat Than Light" by John Midgley, and the subtitle is "The Improbability of a Coherent Energy Policy," and this is rather an interesting article, most of it.

At the end he says this, which kind of presents what we are up against, and that is why we are interested in trying to find the quickest way we can to relieve us of our dependence on foreign sources:

> The Secretary-to-be (of the Department of Energy) was, of course, Mr. James Schlesinger, Jr., and January found Mr. Schlesinger in the White House as chief energy man, coordinating measures of defense against the great freeze. Because

of his experience in the Rand Corp., the Atomic Energy Commission, the Central Intelligence Agency, and the Pentagon, he is mostly thought of as an all-purpose technocrat, which he is in a way; but he is also a Harvard economist and an incurable teacher. In the intervals of deciding how to get some gas to West Virginia or Pennsylvania, he was ordering his thoughts about the future. This included rereading the writings of an Oxford economist, Sir Hubert Henderson . . .

Are you aware of him?

Mr. FRI. No.

Mr. YATES [continuing].

. . . on the dilemma of British economic policy after the second world war, some of which Schlesinger had photocopied to hand out to people seeking enlightenment.

Henderson was talking about a ravaged economy in which the difficulty of bringing aggregate demand and aggregate supply into line was enormous; no lesson for Americans there. Narrowed down to apply just to the energy economy of the United States, the analogy ceases to be farfetched. Demand for natural gas 50 percent in excess of supply. Domestic oil production falling while demand rises. Coal, the inevitable substitute, blocked by technological deficiencies, geographical problems (lack of water in the West), and environmental hazards, most of which apply to nuclear energy as well. Oil imports filling the gap, just reaching half the total level of oil consumption and on their way up. No teacher can ask for a worse object lesson than that.

Are you inclined to agree with Hubert Henderson as to what our plight is?

Mr. FRI. I think that is a good characterization.

Mr. YATES [continuing].

Henderson's argument was that an unregulated price system was "a fair-weather system," useful when demand and supply were not far out of balance and only small price adjustments were wanted. He was arguing against both the Socialists who wanted Government controls forever and the free-market zealots who maintained that the economy would be liberated and healed if only the Government would take the lid off. More likely, he thought, it would go temporarily crazy.

With that kind of picture you can see the burden that rests on ERDA and burden on this committee in trying to push ERDA faster. That was the reason we tried to find out about the figures that you said that you were quoting for oil shale which we thought yesterday was the most promising avenue we had for moving ahead more rapidly.

Dr. WHITE. That is why we asked for double what we had last year.

Mr. YATES. $43 million is all you want for the next year, right?

Dr. WHITE. Yes.

HIGH-BTU GASIFICATION

Mr. YATES. So we move on then.

Now we will turn to High-Btu gasification. You have requested a $7 million increase to $51,200,000 under the subprogram, and this is basically for funding the existing pilot plants and the work on two new processes, hydrane and catalytic gasification.

What are the projected economics in your pilot plants you have in operation? What is the comparison between existing costs of natural gas and what the cost of the gas that you obtain from those plants likely to be?

Dr. WHITE. The cost of gas from the improved second generation plants like HYGAS is of the order of $3 to $3.50 per million Btu's. We have some optimistic numbers down as low as $2.75, but I think our ball park numbers are in the $3 to $3.50 level, substantially higher

than the $1.75 that the President currently suggests as a relief for new gas.

Mr. YATES. Within the ballpark it is to be expected in the event that regulation comes off, isn't it?

Dr. WHITE. Intrastate gas, which has been unregulated, is still well below $3 to $3.50. There have been sales as high as $3 but most of it is in the $2.25 to $2.40 range, I believe.

Mr. YATES. When you talk about price, do you take into consideration the total investment of the plant?

Dr. WHITE. Oh, yes.

Mr. YATES. All the research and development and everything else?

Mr. WHITE. The R. & D. numbers, I don't believe, are figured in that. Since most of this has been sunk cost to the taxpayer, it is not estimated in the cost to be recovered by a private sector operator who would build such a plant. However, one of the things we have to keep in mind is that the cost of coal and the capital charge for that plant represent a very large part of the final cost of the gas, and the amount that it can be varied by process improvement is developed at this point.

Mr. YATES. If the private industry were to develop it, it would take into consideration its research costs, wouldn't it?

Dr. WHITE. My own experience on the energy side of the business is that while obviously the research costs have to get covered in the total operation, the sunk costs don't normally get cranked into the actual estimate of a particular product.

HIGH-BTU DEMONSTRATION PLANT

Mr. YATES. Are any of the processes you have been developing part of the high-Btu gasification demonstration plant?

Dr. WHITE. The COED process which was developed under the Office of Coal Research before we were formed is the first step of the process proposed by the Illinois Coal Gasification Group, one of the two. The Conoco proposal, which is the other one, is based on a slagging Lurgi which was tested at Westfield, Scotland, in a semiwork stage under private funding.

Mr. YATES. Nothing from your existing plants?

Dr. WHITE. The major second generation which we talk about so often, Synthane and HYGAS, are not present in those two demonstrations.

Mr. YATES. If the processes you have developed aren't part of the demonstration plants, of what value would the research be?

Dr. WHITE. The expectation is that they will represent a further improvement in costs and in operability, and something like a CO_2 Acceptor, which is particularly useful for lignite, represents really an application to a specific type of coal.

Mr. YATES. The impression I have is it may have been the Thomas Alva Edison reply. When he was asked about the 300th test that he had undertaken which had proven unsuccessful. He said, "At least I know now what won't work."

Dr. WHITE. We will have an ample accumulation of that sort of knowledge.

Mr. YATES. I asked you about that yesterday, and it wasn't very much at that point.

Dr. WHITE. The thing we are trying to do is avoid going beyond the pilot plant stage in anything like that.

TEST FACILITY VERSUS DEMONSTRATION PLANT

Mr. YATES. The Committee on Science and Technology wants a high-Btu gasification test facility rather than demonstration plants. Are you inclined to favor that approach?

Dr. WHITE. Not generically for a couple of very key reasons. We feel that one of the things you are looking for in a demonstration plant is to show clearly what the economics would be of an integrated operation when expanded to commercial scale. A test facility by its very nature tends to be more flexible than anyone would build if they were building for a specific type of operation, so that it isn't going to represent as good a test of economics and operability of a carefully designed integrated facility. Also, because a test facility has that flexibility and it would be used for various types of commercial development, it would not be of interest, we don't believe, to the private sector to cofund such a facility. They might pay rent for testing their particular component on it, but it would have to be essentially a Government-owned, contractor operated facility.

Mr. YATES. Industry wouldn't be particularly interested that type facility?

Dr. WHITE. If the Government is going to build one they might say fine, but in terms of putting in their own money, I think not.

Mr. YATES. How would the construction of that facility affect the commercialization of gasification technology schedule?

Dr. WHITE. Considering we are now in a late stage of negotiation with plants that have already been pretty thoroughly designed, certainly in terms of the basic concept—we know what the economics are—we would expect it to put the program back about 2 to 3 years.

Mr. YATES. Mr. McKay.

Mr. MCKAY. Put the program back?

Dr. WHITE. You start from scratch now. Where do you put it?

Mr. MCKAY. Your comment about the moving to commercializing, if I got the earlier question correctly, that you wouldn't want to go that route——

Mr. YATES. That was a test facility.

Mr. MCKAY. Just a test facility. You are not talking about a commercial size unit which I would not favor.

Dr. WHITE. No.

Mr. MCKAY. Because private enterprise would not be willing to go into that. You are talking about a test facility?

Dr. WHITE. Test facility as such.

Mr. YATES. What I was asking him related to the proposal of the Committee on Science and Technology, just to create test facilities and that is what this particular discussion was about.

Dr. WHITE. We have a commitment to come back to them with a plan of how would we do this, if we did it.

Mr. MCKAY. I misunderstood then. Because I think there are some companies who are ready to go in a combined effort for a commercialized situation.

Dr. WHITE. Oh, yes.
Mr. YATES. Mr. Murtha.

SMALL SCALE VERSUS LARGE DEMONSTRATIONS

Mr. MURTHA. Dr. White, wouldn't we be better off having a number of small installations directly related to commercial, or adapted, to commercial projects and you monitor them and work with them in testing and evaluating rather that a couple big demonstration projects? It is the opposite of what you are saying.

Dr. WHITE. One of the features of the demonstration plants that we are trying to build into them is that by their location, by their resource availability, and by the degree of commercial similarity, even though they are smaller, that they are expandable by either building more of the same side by side, or enlarging to go commercial after the demonstration period is finished. We would hope that in these cases we will be able to interest the participant in buying out the Government's share and going commercial. Therefore, we have tried to select demonstration plants in such a way that they can be adapted to that if they are successful. Of course, if for some reason they should fail technically at the demonstration scale, either processwise or because of environmental problems, they would have to be written off.

Mr. MURTHA. What I am thinking though is, isn't the technology at the point where it could be adapted to a commercial installation on a smaller scale and have a number of these things going at the same time, say 300 or 400 at $1 million rather than 1 at $200 million?

Dr. WHITE. Mr. Murtha, the nature of the processing is such that for the gasification operation, for High Btu particularly, the economies of scale are very significant, and I think if you are talking small ones you are going to be talking $9 and $6 gas instead of $3.50 gas.

Mr. MURTHA. At this point it is not commercial?

Dr. WHITE. This does not apply to the little gasifiers as Mr. Fri mentioned yesterday. These are now commercially available for a low-Btu gas, and you can buy these. It is obviously still more expensive than a big one. You wouldn't want to buy a lot of little ones and stick them side by side, but they are not far from being commercially attractive today.

Mr. MURTHA. Thank you.

ERDA-AGA COOPERATION

Mr. YATES. The AGA cooperates with you in helping fund pilot plants.

Dr. WHITE. Yes.

Mr. YATES. They don't for demonstration plants. Why is that?

Dr. WHITE. Well, the proposers for demonstration plants have been specific companies or groups of companies that are interested in developing a technology in which they have a certain amount of proprietary technology. In Hi-btu, there is a proprietary interest in their technology, part Government and part proprietary, and they also see the eventual commercialization of this facility hopefully.

The AGA is not in the business of trying to commercialize a gas-producing facility. They just want the technology as industry representatives to move along.

Mr. YATES. Whatever results are achieved from that research are made available to the public, aren't they?

Dr. WHITE. Yes.

PATENT POLICY

Mr. YATES. What happens on your demonstration plants? Are any discoveries coming from your demonstration plants patentable to the companies and to the United States, or both, or how do you share this?

Dr. WHITE. Let me answer that and then stand to be corrected if I don't have it straight. Mr. Rial, I think, is more familiar with it.

The contracts are being written, I believe, in both these High-Btu gas cases in such a way that the patents will be held, if there are any foreground patents in this operation, by the contractor with a requirement to license to all responsible parties. There is a royalty-sharing arrangement that reflects the cost sharing of that demonstration, essentially a 50–50 cost sharing with the Government. Is that right?

Mr. RIAL. That is correct. We are developing the royalty in relation to the cost sharing so any development of a foreground patent will be 50–50 by industry and the Government, and industry is required to license at a reasonable rate.

Mr. YATES. Is required to license at a reasonable rate. Does the Government share in that license?

Mr. RIAL. Yes, sir.

Mr. YATES. And you would be participating in determining what that licensing fee would be, right?

Mr. RIAL. Right.

Mr. YATES. Is this true with respect to oil shale too? You are going to provide Oxy with $45 million and it is going to put up a proportionate share as well?

Dr. WHITE. Same deal.

Mr. YATES. You say the same deal.

Dr. WHITE. Yes, we expect the arrangement to be similar.

Mr. YATES. And the same answer with respect to any patentable items that come out of it?

Dr. WHITE. Yes. Very clearly the major group of basic background patents is held by Oxy already, and what we are talking about is the incremental patents that would come.

Mr. YATES. Some refinements of it that may happen. All right.

LOAN GUARANTEES

There was a March 11 article on a joint project between the American Natural Resources Co. of Detroit and Peoples Gas Co. of Chicago which would require Federal loan guarantees. Do you have the power to make Federal loan guarantees at the present time?

You don't? That legislation wasn't passed. All right. I don't know the basis for that.

Dr. WHITE. Mr. Myerson is our Division Director for Commercial Applications.

Mr. MYERSON. We do not currently have the authority to make loan guarantees.

Mr. YATES. Are they going ahead without the loan guarantee then?

Mr. MYERSON. No, they are seeking loan guarantees.

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Mr. YATES. But you haven't the authority and they are seeking it.

Mr. MYERSON. We are seeking the authority.

Mr. YATES. I see. You are both seeking it.

LOW BTU GASIFICATION

Mr. YATES. This program was increased by $41 million to $73,900,000, for three projects primarily: a "combined-cycle" test facility, Powerton; a hydrogen from coal facility; and a program on gasifiers in industry.

What is the status of the Powerton project?

Dr. WHITE. The Powerton project is coming to a May 1 deadline of what have been some very difficult negotiations, but having just come off the telephone from their vice president, I think we are just about together. We should be wrapped up and ready to sign at least a letter of contract next week.

Mr. YATES. Has a contract been awarded yet on your hydrogen from coal facility?

Dr. WHITE. Do you know what is scheduled, Dr. Neuworth?

Dr. NEUWORTH. I expect an award in another 2 weeks. There are two potential bidders.

Mr. YATES. Where are you going to get all the coal for all of these projects if they are successful with all the obstacles in the way?

Dr. WHITE. The coal for these projects is really a rather nominal amount.

Mr. YATES. I know. Suppose they are successful. Who is coordinating all this?

Dr. WHITE. We really have the full expansion of coal supply coordinated in a broad sense in the administration.

Mr. YATES. We look to Dr. Schlesinger for that.

Dr. WHITE. As Mr. Fri says, this is one of the things that will come out of the new Department, to bring all these things together.

Mr. YATES. Let's hope so.

GASIFIERS IN INDUSTRY

How many gasifiers were in your original package and how many additional gasifiers?

Dr. WHITE. There are six small gasifiers that were awarded or chosen for awards under the Program Opportunity Notice we put out.

We also had larger industrial gasifiers in the demonstration plant program for Low-Btu gas and there are two that have been awarded for design, which will process 500 tons a day, quite a bit larger size, one for a distributive utility in the city of Memphis, and the other in Kentucky to actually make a feedstock for ammonia.

There are two smaller ones in the 200- to 500-tons-a-day range, which have just been announced. Mr. Rial, would you name the contractors for the two smaller ones?

Mr. RIAL. One was for New Jersey Zinc for indirect heating of zinc smelters. One was Erie Mining for taconite.

Mr. YATES. Is this total program?

Dr. WHITE. That is the total small gasifier program.

Mr. YATES. That is the total program including the gasifiers you thought you might want to reprogram for?

Dr. WHITE. We talked about reprograming for more of these little ones like the 6, and it was decided that probably the 6 and the 4 others, 10 of them, was probably enough. It is a matter of judgment.

Mr. YATES. What is your total cost under the gasifier program?

Dr. WHITE. I will have to ask Dr. Neuworth.

Dr. NEUWORTH. The small gasifiers program is $25 million, Government cost.

Dr. WHITE. Actually our share is less than 50–50 in some of those.

Dr. NEUWORTH. About 45 percent.

Dr. WHITE. Mr. Rial, do you have the figure for the four projects in the demonstration plants program?

Mr. RIAL. Yes.

These four will cost the Government about $500 million.

Mr. YATES. Is this to the point where you are going to go ahead and expect industry to build it without Government money?

Mr. RIAL. Money.

Dr. WHITE. The technology that is currently available lacks two key demonstrated aspects to it. One is the ability to use a caking coal, To do this in its present system of the Lurgi-type gasifiers you have to put stirrers in and that has not been done in a way that will handle a strongly caking Eastern Kentucky coal.

The other is the matter of handling the quite obnoxious effluents that come off the Lurgi gasifier. The sulfur dioxide air pollution problems probably have to be handled by conventional means, but this has not been done by a Lurgi gasifier.

LOW-BTU FUEL GAS DEMONSTRATION PLANT

Mr. YATES. What is the status of your low-Btu fuel gas demonstration plant?

Mr. YATES. Of the four contracts mentioned, the demonstration plants are under negotiation. Of the small gasifier projects, three have been signed and three still to be negotiated.

Mr. YATES. When will construction start?

Dr. NEUWORTH. In about a year.

Mr. YATES. Now you want some money for two small industrial fuel gas demonstration plants. When are you going to sign a design contract on these?

Dr. WHITE. Those negotiations are just started. It will take about 6 months, I suppose, for contracts.

Dr. NEUWORTH. We are looking at roughly July 15. These are standard technologies and have minimum impacts.

Dr. WHITE. Those will be signed we hope a lot quicker.

SIZE OF GASIFIERS

Mr. YATES. You want small gasifiers and large ones and you also now want gasifiers in the middle. If they work for small and they work for large won't they work for middle? Are there essential differences in the middle that will require special plants?

Dr. WHITE. There are not critical differences. That is certainly true. The perception of their applicability I think is the main thing we are striving for, to get people to realize that they are useful at this level of gas requirement, and it is something that can be done with existing technology.

Mr. Rial might want to elaborate on that.

Mr. YATES. You have the little and big ones.

Dr. WHITE. Excuse me. In his program, Mr. Rial views them as the small ones, which are the middle-sized ones.

Mr. RIAL. The two small industrial demonstration plants are about 200 to 500 tons a day. Let me just specifically indicate their requirements and their needs. In the one case, Erie Mining is going to run out of gas in 1980. They have a critical need for gas in order to run the processes. This is near the Canadian border. The Canadians are going to shut off the gas.

In this case we are using existing technology to indicate to industry, to everybody in the United States, that you can use these small industrial gasifiers in an environmentally acceptable manner. This is an installation where it is going to be used in taconite processing. This taconite processing supplies about 20 to 25 percent of iron ore in the United States, so it is an important industrial application.

In the other, the gas is used in direct heating in an industrial zinc smelting operation in Palmerton, Pa., so that these are real industrial applications.

Mr. YATES. Where do you draw the line between small and middle and large? What tonnage?

Dr. WHITE. 200 and 500 tons a day. It was a rather arbitrary distinction.

Mr. YATES. For what? What is the small one?

Dr. WHITE. The gasifiers in industry are below 200 tons a day. The small demonstration plants Mr. Rial has just been talking about are in the 200 to 500 tons a day range. The large ones are quite a bit larger.

Mr. RIAL. The Memphis one is about 3,000 tons a day of coal and the Grace/Ebasco one is about 2,000 tons a day of coal.

Mr. YATES. You are building one together with the Erie Mining Co. Who is paying for that?

Mr. RIAL. This is a 50–50 cost sharing.

Incidentally, they are going to buy back so it will only cost the Government at this point roughly about $4 million on a net basis after a 20-year period.

GASIFIER CONTRACTS

Mr. YATES. I can see why it takes time to make these contracts. They are rather complicated, aren't they?

Mr. RIAL. They are exceedingly complicated because you have to look forward to the business arrangements over the next 10, 15 years, and you get into all sorts of questions of allocation of gas, financial resources, and the patent situations. They are not simple negotiations.

While ERDA has its problems, industry also is trying to work out its overall long-term business arrangements.

Mr. YATES. Sure.

Mr. MCKAY. On these gasifiers, we have the technology now. We have done demonstrations so it is feasible; is that correct?

Dr. WHITE. There are existing gasifiers operating in the United States, I think three or four of them, maybe a few more, around the country. They are really the old gasifiers that had been in operation widely throughout the world prior to 1950.

Mr. MCKAY. England uses quite a few still.

Dr. WHITE. Yes, quite a few over there.

GASIFICATION DEMONSTRATIONS

Mr. MCKAY. What I am wondering is are we hung up on demonstrations rather than moving out on the project or is it economics, just not economical enough yet?

Dr. WHITE. I think it has been considered to be clearly uneconomical and environmentally questionable prior to this winter. However, when faced with a shutdown and loss of operations, the economics become considerably more attractive to keep you going. The fact that you can build one of these and run it in an environmentally satisfactory way has not yet been shown by people.

The little ones now I suppose are having to meet continually increasing environmental requirements, but frankly I am not too sure just what they are doing on those.

Mr. Singer, do you have any information on the environmental picture as regards the presently operating gasifiers?

Mr. SINGER. Not any measured data for those commercial gasifiers that are currently operating at three sites in the United States.

Mr. MCKAY. I am just concerned outside of economics. Of course if it isn't economic nobody is going to pick it up. But at the same time if we have the demonstration, it is just a matter of we are just hung up on more demonstrations.

I had a distinct feeling for a long while we have been hung up in laboratories and demonstration projects and we cannot seem to get out of it, as I expressed.

Mr. FRI. Take the New Jersey Zinc Co. which smelts material in a refractory furnace. They have to keep some kind of gas supply to keep that furnace going. They cannot have the supply shut off or the refractory tends to crack and so forth. So they look at the economics, and they look at the reliability of the process and environmental impact. They want it so long as it meets basic criteria—am I going to make some money on it? Am I going to get away with meeting the EPA regulations?

The nature of this demonstration is not so much to prove a new research concept as to prove to a businessman, who is investing his stockholders' money, that he can operate one of these machines and make money at it; that it is reliable; and that it meets the environmental standards. Those are the hurdles that have to be crossed with this kind of demonstration to convince businessmen that it is a legitimate investment.

The economic competitiveness is a prerequisite, of course, but not by itself sufficient. So the nature of this kind of project is to really convince people that it makes sense to make this decision. It is that kind of "get on with the demonstration" that we are really engaged in.

Mr. MCKAY. Did you indicate earlier a time frame when these would be demonstrable or when you reached the answers you are after?

Dr. WHITE. These projects could be negotiated by July, and if they are, there is no reason that they shouldn't be in operation within at least 3 years, perhaps 2½.

Mr. RIAL. Our schedule shows that they will be in operation in the latter part of 1980.

Mr. MCKAY. That would be in operation. You wouldn't know until then that they were totally successful?

ENVIRONMENTAL QUESTIONS

Mr. RIAL. Well, there are traditional technologies. We know they are going to be a success, technically. What we don't know is if it will be environmentally acceptable in terms of the community.

Dr. WHITE. As to the applicability/operability factor, we are reasonably confident, but it hasn't been proven that these sizes and these types of application will do what is needed.

Mr. MCKAY. You may by the environmental techniques throw the whole chemistry out of wack. That is what you are wondering about.

Dr. WHITE. New Jersey Zinc used it 25 years ago until gas came in. As you are probably aware, the Palmerton area is a pretty bad place from an environmental standpoint.

Mr. YATES. Is the Palmerton area in Mr. Murtha's district?

Dr. WHITE. I don't know.

Mr. MURTHA. No, it is not. We have a gasification project in the district, High-Btu project in Indiana.

Mr. MCKAY. Then industry is going to be waiting until 1981 to see whether this proves out and at that point then they will start planning and moving, hopefully, if your projections are accurate, so we are looking at another 1985? Is that about right before you get any major impact through the industry?

Dr. WHITE. Let me just make one caveat on that. If they are hurting enough, they may decide to move out with a damn-the-torpoedoes sort of philsophy, and decide to just take a chance on it.

Mr. MCKAY. Unless EPA shoots them down.

ADMINISTRATION'S POSITION ON COAL DEVELOPMENT

Mr. DICKS. Will the gentleman yield?

I thought one of the things Mr. Carter was going to do in his energy program as related to coal was to try and provide certainty and try and provide regulations as to what the Government's position is going to be at this point so that these kinds of investments can be made. Has this been done or not?

Dr. WHITE. It certainly has not been done to date.

Mr. FRI. It is one of the 10 basic principles under his policy, and he has several proposals to do that. That policy also has a fail-safe mechanism which says "if for some reason the environmental regulations change, you get a 20-percent tax credit and a 5-year fast writeoff on investments which were made to upgrade your environmental controls."

Mr. DICKS. So there wasn't anything done, in other words, basically?

Dr. WHITE. This is in the plan before Congress.

Mr. YATES. It is something we have to pass on.

Mr. FRI. The environmental uncertainty will not be resolved until something is done to clarify the two questions of non-attainment and significant deterioration. Until the question of best available technology is resolved, uncertainty will result. It is the President's view to get those questions nailed down; however, if we are not able to develop a permanent set of criteria, let's admit it and give industry a special tax break.

CLEAN COAL TECHNOLOGY

Mr. MCKAY. The best available technology theory could have them remodeling those plants once a year to where there is no end to it. There is no certainty gained there.

Mr. DICKS. You would have a proven best available technology and all of a sudden you have a breakthrough on how you clean coal or how you handle it before it is burned. Then you are going to require these companies to install that? Is that what we are saying when you say best available?

Mr. FRI. Well, it varies. On new plants, it is the best available technology at the time of the new plant.

Now, there has occasionally been a pour-over effect into the existing plants which is something it seems to me ought to be handled rather more systematically than it has been. That is how the scrubber problem got started. The scrubber started out on best available technology on new plants and the next thing we knew it was a retrofit technology for old plants.

RETROFIT TECHNOLOGY

Mr. MCKAY. That is the hook. It puts them into uncertainty if you start forcing the retrofitting.

Dr. WHITE. Isn't there some 10-year provision in the plans?

Mr. FRI. Yes. If the rules change within 10 years, you get this fast writeoff and 20-percent tax credit.

Mr. DUNCAN. What was the third one, besides nondegradation and best available technology?

Mr. FRI. Nonattainment.

Mr. DICKS. What does that mean?

Mr. FRI. That is the concept in which you take a specific air quality region which has not yet met the standard, and you cannot put in a new facility that would emit additional pollutants unless you can somehow or another reduce, from the existing sources, the amount of pollutants that the new facility would introduce. That is why the Volkswagon plant is in trouble in Pennsylvania.

Mr. DICKS. That is why the Sohio pipeline, the oil transfer situation on the West Coast has problems. You have to raise up the air pollution in the area unless you kind of buy your piece of pollution to substitute.

Mr. FRI. Something like that. Hydrocarbon emissions on the West Coast would behave this way.

ADVANCED POWER SYSTEMS

Mr. YATES. Let's turn to the power systems.

You want $3 million above 1977 for a figure of $25,500,000. You say that in open cycle gas turbines there will be required $307 million for

the total development program. Over what time period is that projected?

Dr. WHITE. That period I think is 6 to 8 years.

Mr. YATES. What industrial cost sharing will it be?

Dr. WHITE. At this point those programs are 100-percent Government funded in developing the technology. We really have not addressed the matter with potential vendors of what possible sharing there would be in that. When we reach the part of really building hardware rather than just doing R. & D. on the components, we would attempt to get Government cost-sharing.

Mr. YATES. Is the Government doing R. & D. on the components?

Dr. WHITE. At the present; yes.

Mr. YATES. Then who are your major contractors? Who are you working with?

Dr. WHITE. Four turbine manufacturers: General Electric, Westinghouse, Pratt-Whitney and Curtiss-Wright.

Mr. YATES. Does General Motors make a turbine?

Dr. WHITE. Not this type. They make automotive turbines.

Mr. YATES. Is there a relationship between your turbine program and the conservation program?

Dr. WHITE. The conservation people are concerned about automotive turbines as an alternate power source, and if we decide to allocate our program this way, we are concerned with turbines which are based on coal as fuel and, therefore, dirty fuel.

Mr. YATES. I think conservation also has a power turbine.

Dr. WHITE. Yes, on clean fuel, and we try to be very closely coordinated in this, but when it comes to these turbines that have to handle the dirty fuel with particulate and sulfur residuals, you have to clean them up as much as you can, but you cannot take it all off. Then is when we get into it.

PROBLEMS IN TURBINE DEVELOPMENT

Mr. YATES. Do you have any problem in developing the turbines?

Dr. WHITE. The main advantage of the combined cycle is that it is only achieved if you get from the present 1,800 degrees up to about 2,400 or 2,500 degrees, and to make a turbine that is durable at that temperature and will tolerate coal-derived fuels is a difficult technical problem. It is primarily a technical obstacle at this point. It has to be either water-cooled, or be a ceramic.

Mr. YATES. How does it compare with the blades they have in the jet engines?

Dr. WHITE. Much higher temperature.

Mr. YATES. Will they be available commercially?

Dr. WHITE. There is nothing available commercially now. They are just being developed under these contracts.

CLOSED CYCLE TURBINES

Mr. YATES. If the open cycle turbine proved successful, are you going to drop your work on closed cycle?

Dr. WHITE. I would except we would; yes. Closed cycle is really a hedge against open cycle just not working.

Mr. YATES. How long will it be before you think you will be required to make that judgment?

Dr. WHITE. I would like to defer to someone else. Does somebody want to guess? Perhaps 4 years.

Mr. YATES. Four years, maybe.

DIRECT COMBUSTION

Mr. YATES. Let's turn to direct combustion now.

You have a fluidized bed boiler in, of all places, West Virginia.

Dr. WHITE. Prior to ERDA's formation.

Mr. YATES. All right. How has that 30 megawatt pilot fluidized bed boiler worked out?

Dr. WHITE. We are happy to say that—it was in three stages—finally we got coal burning in the third stage.

Mr. YATES. How does it look?

Dr. WHITE. It looks pretty good so far. It is quite encouraging.

Mr. YATES. When you say quite encouraging, what does that mean?

Dr. WHITE. It will run.

Dr. NEUWORTH. I think it represents an alternative to burning high-sulfur coal in which the utility industry is quite interested.

Mr. YATES. How long will it be before you come to any conclusion on this?

Dr. NEUWORTH. We would like to run a 1,000-hour run.

Mr. YATES. How many more hours do we have to wait for that? Is it running now for the 1,000-hour run?

Dr. NEUWORTH. No.

Mr. YATES. When are you going to start that?

Dr. NEUWORTH. We have external problems. Coal handling has been the problem, rather than the boiler itself.

Mr. YATES. What does that mean? You cannot get the coal?

Dr. NEUWORTH. At times the feeding system gives us difficulty.

Mr. YATES. When are you going to work it out?

Dr. NEUWORTH. As soon as we can.

Dr. WHITE. I would say there is a great deal riding on this, because if we do work out these problems, then some of the aspects of a commercial utility type fluidized bed boiler will be in hand and we will be able to think about designing a commercial unit.

COMPONENT TEST AND INTEGRATION UNIT

Mr. YATES. Now you are going to build another plant in Morgantown, W. Va., in 1978. How does this operate in relation to that?

Dr. WHITE. The 30-Mw pilot plant at Rivesville was designed back in the days when we had budgets of a few million dollars, and it was very sparsely designed and was really just to try the basic concept. One of the features of this facility that is really not commercial is that the three cells are horizontally side-by-side. But when you consider the area, that would be required for a commercial utility, it would be unreasonable to have the cells side by side. The only way to do it is to stack the cells vertically. This has not been done.

The primary feature of the Morgantown test facility is to have vertical stacking, and all of the other features of a test facility that can be played with and shut down without disrupting things.

Mr. YATES. It suddenly occurs to me that you are engaged in an enormous enterprise. Do you have enough design people? Are there enough engineers and designers in the country to take care of ERDA's program?

Dr. WHITE. This has certainly not been a limiting factor so far. There have been a lot of good design firms who have people. We don't do it all, obviously.

Mr. YATES. You don't do it in-house obviously.

SCRUBBERS

Do you have any data to indicate that scrubbers will not be necessary for fluidized bed boilers?

Dr. WHITE. The data we have, operating little bench scale units, and even so far at Rivesville, I think would show that with a normal, even high, sulfur coal, the present EPA standards would be met with a fluidized bed. If the standards get much more severe for sulfur, we may have difficulty.

Dr. NEUWORTH. You do have flexibility on how much limestone can be used but it is true, and would be equally true of the flue gas scrubbers, that if you make the requirements much more severe, they will have to have multiple units.

HEALTH EFFECTS

Mr. YATES. Should we ask the former Administrator of EPA that question. Are you going to make the requirements much more severe? Can you?

Mr. FRI. There is a major debate going on right now as to exactly how one goes about controlling sulfur and the nature of the debate is the following: That one group believes it is the surfur oxide itself, the gas, that must be controlled.

There is another view held by equally reputable people, so far as I can tell, who say that is not the problem. It is the sulfates and the sulfates are particulate matter, and they adhere to small particles and, therefore, what one wants to worry about are the small particles that you can inhale into the lungs but don't come back out again. These are micron-size particles and the right approach to the control, therefore, of the sulfur problem is to design precipitators that will take out these micron-size particles efficiently, which currently precipitators will not do.

Until that issue is resolved as a scientific matter, what is really causing the adverse health effect, I think it is premature to crank down the sulfur standards.

Mr. YATES. Is this a question of cancer carcinogens?

Mr. FRI. Yes.

Mr. YATES. How do you know? You step over a period of time. I am told by at least some of the cancer experts at the NCI that you don't know what is going to happen except for the passage of 20 or 25 years.

Mr. FRI. There are two things one can do. First of all EPA, and its predecessor agency before it, has had a long-term health effects study going on where a number of people around the country are monitored. That is a long-term experiment that has been under way for 10 or 12 years, which will help give health effects data.

The other way to approach it is clinically, by examining what is going on inside the lung and trying to understand the physical process that is under way. I am quite sure that both kinds of research are going on, but there is quite a scientific argument over just exactly what the adverse health effect process is.

Mr. YATES. When will that be resolved, or don't we know?

Mr. FRI. I am afraid I don't know the status of that.

Mr. YATES. Is this something you will have to resolve or the Congress will have to resolve?

Mr. FRI. I think the Congress in the end will have to concur in the resolution if not resolve it itself.

Mr. YATES. Mr. Murtha.

ENERGY EFFICIENCY

Mr. MURTHA. What is the advantage in the efficiency of the fluidized bed versus the present technology?

Dr. WHITE. Both of them will preempt about the same amount of sulfur.

Mr. MURTHA. I am talking about the energy efficiency.

Dr. WHITE. I think I will have to ask Dr. Neuworth.

Dr. NEUWORTH. You have a lower per unit cost.

Dr. WHITE. The scrubbers typically are about 3 to 6 percent of the energy cost.

Dr. NEUWORTH. The fluidized bed has no scrubbers.

Mr. MURTHA. So you are picking up 3 to 6 percent in energy efficiency? Is that what you are saying, in labor and materials?

Dr. NEUWORTH. Yes.

Dr. WHITE. You have to bring in the limestone. There will be a certain amount of cost.

Dr. NEUWORTH. The energy cost of that is very low. In both cases you have to dispose of limestone and there is a larger amount in the fluidized bed, but it is dry.

Mr. MURTHA. So the advantage then is in pollution control rather than in energy efficiency? There is no breakthrough in energy efficiency?

Dr. WHITE. No great breakthrough in energy efficiency. It is largely an operability factor. It is a lot easier to operate a fluidized bed, if we make it work right, than it will be to operate with a scrubber. The scrubber is a few percent less energy efficient.

Mr. FRI. With 400,000 megawatts of installed electrical capacity, a few percent can be a fair amount of energy.

Mr. YATES. Why are you going ahead with the construction of large fluidized bed projects before you know the results of your experiment at Rivesville and Morgantown?

Dr. WHITE. We are not going ahead with the actual construction. We are trying to keep the design moving as fast as we can and get an idea of what is involved. One of the things that helps to focus attention on the kind of design that we should get is to run those smaller units to provide the necessary data.

Mr. YATES. Then your design work is just going ahead and it is flexible enough to be moved by what happens at Rivesville.

Dr. WHITE. Yes.

Mr. MURTHA. Back to energy efficiency again, is there a possibility you could have an increase, some kind of a breakthrough, or is that not probable?

Dr. WHITE. I don't believe so. What we have been talking about is atmospheric pressure fluidized bed combustion. You can raise the pressure of the fluidized bed which does give you an increase in that it basically reduces the size of the unit because you put it under pressure.

Mr. MURTHA. If you had to add scrubbers, you would have a decrease in efficiency, so you are looking then at scrubbers as being only negative for sure, and the fluidized bed as a possible of increasing the energy efficiency.

Dr. WHITE. Yes.

TVA FLUIDIZED-BED DEVELOPMENT

Mr. YATES. Just for the record. What is your relationship to TVA? TVA is building a fluidized bed demonstration plant. Are they doing it with your money? Are you going to finance a TVA plant?

Dr. WHITE. We are both looking at the concept design.

Mr. RIAL. We are working cooperatively with EPRI and TVA on the total program. TVA plans to go ahead with one fluidized boiler installation at some time. We are funding TVA to the extent of a million and a quarter dollars for their design studies. From then on TVA is on their own.

TVA is doing one design study. We are doing two, and we are making all of our available to TVA and vice versa.

The two we are doing includes one at about 600 megawatts which will be a strict comparison with a conventional boiler with scrubber. The other design is a 200 megawatt design where we are looking at that as a potential demonstration plant, assuming EPRI wishes to sponsor it with one of the electric utilities.

Mr. YATES. TVA is really in trouble, isn't it? It is following, I understand, very bad law.

Mr. RIAL. They have a high urgency for going ahead with the program.

Mr. YATES. If they build the plant themselves would boiler manufacturers be able to build commercial plants based on TVA's operation?

Mr. RIAL. Yes. What TVA is doing in their one design is getting proposals from three main suppliers and they are going to then select one as a basis for their specific design.

Mr. YATES. They can go ahead faster than you can. They don't have to worry about competition.

Mr. RIAL. To some extent they can. They can pick a site, and they have less rigid procurement requirements, but still some of the same ones that we have.

INDUSTRIAL APPLICATIONS PROGRAM

Mr. YATES. You have four contract awards for the industrial applications program. Georgetown University has one of your contracts. How many contracts are you ultimately going to let? What will the ultimate cost be?

Dr. WHITE. Dr. Neuworth, could you answer that?

Dr. NEUWORTH. There are four.
Mr. YATES. That is what we said.
Dr. WHITE. That is all, isn't it?
Dr. NEUWORTH. Yes.
Mr. YATES. What is the total cost likely to be, Dr. Neuworth? Any cost sharing?
Dr. NEUWORTH. Yes; overall, about one-third cost sharing.
Mr. YATES. One-third by Government?
Dr. NEUWORTH. No. It works out to about 50 percent in the construction and operation phases.
Mr. YATES. Is four going to be your total?
Dr. WHITE. I think so.
Mr. YATES. Is there any possibility of this technology becoming commercial?
Dr. NEUWORTH. Yes. These will be commercially operated after ERDA withdraws from the program.
Mr. YATES. When do you do that?
Dr. NEUWORTH. After about 2 years of operation.
Mr. YATES. A thousand hours?
Dr. NEUWORTH. Hopefully.

PRESSURIZED FLUIDIZED-BED BOILERS

Mr. YATES. What is the status of your pressurized program?
Dr. WHITE. The pressurized program is really made up of three main contracts. There is a contract with Curtiss-Wright to have a pressurized pilot plant which is now well under construction. I guess it will take another year for completion. There is a plan for a facility that will be somewhat analogous to the one at Morgantown to be built at Argonne which is just in the design stage now. It will be a pressurized test facility. Then, part of the international agreement with IEA is to have a pressurized unit in the United Kingdom which is sponsored by the United States with ERDA funding, West Germany, and the United Kingdom. That is just now being designed.
Mr. YATES. Is that the one with American Electric Power?
Dr. WHITE. No. American Electric Power is going ahead on their own without any Government funding. We had talked to them originally about possible cooperation. They are keeping us reasonably well informed but it is private funding.
Mr. YATES. Is our technology as good as that of any of the foreign countries?
Dr. WHITE. No one has any operating technology in this yet, the pressurized fluidized bed.
Mr. YATES. What about design? What about pilot programs? Is West Germany ahead of us?
Dr. GOUSE. No; we are actually a little ahead. The most advanced project today is actually the one in the IEA project.
Mr. YATES. IEA?
Dr. GOUSE. International Energy Agency.
Germany is building a facility on its own similar to what we are planning to do at Argonne, and those two are at about the same stage.

INTERNATIONAL ENERGY DEVELOPMENT

Mr. YATES. Where are we? I suppose this policy is really in review. Where are we in respect to all of our technologies? Are we behind any of the foreign countries in terms of energy? Are we behind West Germany in any technology? Are we behind the British or the French or the Japanese?

I am not only talking about the pressurized boiler.

Dr. WHITE. Just coal gasification.

Mr. YATES. No; everything.

Dr. WHITE. The one obvious place where I guess we would have to say we are in some respects behind the Russians would be in magnetohydrodynamics, MHD.

Mr. YATES. Behind the Soviet Union.

Dr. WHITE. In terms of their application of that technology to natural gas. They are not doing it on coal.

Mr. YATES. Which is what we don't want.

Dr. WHITE. We hardly want to use our gas that way. The approach used by the South Africans which was used originally by the Germans for coal, was actually a gasification operation, they are ahead of us on that because they have operated that commercially, but it is a very expensive and energy inefficient process.

Mr. YATES. South Africa is not ahead of us.

Dr. WHITE. In the commercial operation of that process they are, but that is not one that we would find attractive.

CONVERSION OF UTILITIES TO COAL

Mr. YATES. How are you going to get utilities to switch to coal, or is that FEA's problem?

Dr. WHITE. Just give them an order.

Mr. FRI. FEA has a mandatory coal conversion program, but hopefully the availability of things like fluidized bed combustion and a pricing policy will be additional encouragement.

Mr. DUNCAN. Mr. Chairman.

Mr. YATES. Mr. Duncan.

FLUIDIZED-BED PROCESS

Mr. DUNCAN. I hate to be an idiot, but in about three sentences tell me about this fluidized bed. What do you do? Mix oil and coal together?

Dr. WHITE. In the fluidized bed, instead of just injecting fluidized powder, there is a grate near the bottom of the boiler. Above that, there is limestone or dolomite which reacts with the sulfur dioxide.

Mr. DUNCAN. Is that called sorbent?

Dr. WHITE. Yes, that is generic.

Mr. DUNCAN. That is either a dolomite or a limestone.

Dr. WHITE. Yes.

Mr. YATES. What happens after that?

Dr. WHITE. It becomes essentially a gypsum-like material, a calcium sulfate that has to be disposed of. It is not of any particular value.

Mr. DUNCAN. So that is where it soaks up the impurities and pollutants?

Dr. WHITE. Yes.

Mr. DUNCAN. But the fluidized concept is that coal is ground?

Dr. WHITE. Ground, and it is not liquid. It acts like a fluid and you can move it around.

Mr. DUNCAN. It is not a combined combustion process?

Dr. WHITE. No.

LOW-BTU AND HIGH-BTU GASIFICATION

Mr. MURTHA. Mr. Chairman, while he is explaining, could you explain the difference between Low Btu and High Btu and the type product you use and what comes out in the end?

Dr. WHITE. The High Btu is essentially the same thing chemically as natural gas and, therefore, is suitable both in transportation through pipelines and for residential and industrial application. The Btu content essentially of natural gas is typically 1,000 Btu's per cubic foot, Low Btu about 100 to 300 Btu's per cubic foot, and Medium is 300 to 500 Btu's per cubic foot. It is not practical to transport the Low Btu because it is so diluted. You can move it maybe 10 miles but you cannot ship it across the country. It can be used, however, in many applications where a clean gas is needed for industrial purposes either just for heating or for processes like the brick kiln where you are impinging it right on the product. It is not practical to form Low Btu gas and then try to convert it chemically up to High.

If you have an oxygen plant you can upgrade the gas by getting rid of the nitrogen, and you get what is usually referred to as Medium Btu gas.

Mr. MURTHA. Do you use a different type of coal for these processes?

Dr. WHITE. No; the same for any of them.

Mr. MURTHA. For either process, High Btu or Low Btu?

Dr. WHITE. Yes. It can be used. There may be small advantages for the one because of chemicals.

Mr. MURTHA. Is the cost for the High Btu less than the Low?

Dr. WHITE. No; the Low Btu is less, because you have a lot of processing in the High-Btu gas.

FINELY POWDERED COAL

Mr. YATES. For Mr. Regula's benefit can you tell us what your assessment of the process for finely ground coal by Dr. Ilok is? And Ohio State University?

Dr. WHITE. Dr. Ilok has made for many years very extravagant claims for the finely powdered coal. There has been a great dearth of hard data about that, but I believe recently he has agreed to provide samples and data.

Dr. NEUWORTH. Yet to come.

Dr. WHITE. He has agreed, but nothing has happened.

Mr. REGULA. Will the chairman yield?

Mr. YATES. Of course.

Mr. REGULA. Isn't this used by the utility industry in effect, though, with their spraying methods of powdered coal? Or it is mixed with some petroleum products in a combustion chamber?

Dr. WHITE. No, it is not nearly that finely ground. Dr. Ilok alleges that if it is ground down to the four micron size all the bad things fall out. It separates so you get all the sulfur and ash separated in the coal.

Mr. REGULA. You get down to a compound I assume. How does it fall out? You spray them into the combustion chamber.

Dr. WHITE. I think he separates them first.

Mr. REGULA. In the grinding process.

Dr. WHITE. No; after the grinding. You then can separate them and heavy ash will fall out and the coal particles will lift to the top.

Mr. REGULA. Isn't this the assumption that sulfur is part of the ash?

Dr. WHITE. Yes. What about the sulfur that is tied up in the organic part of the coal? It is not clear why that should fall out then.

Mr. REGULA. And the experimentation has not been done yet.

Dr. WHITE. It is not that simple.

Mr. REGULA. So that the objective is that this would be an alternative to scrubbers?

Dr. WHITE. Yes. There are other ways to clean coal chemically that are being worked on quite intensively around the country, largely financed by the Bureau of Mines. We are working very closely with them because there is obviously interaction.

COAL-OIL SLURRY

Mr. YATES. Let's talk about coal-oil slurry. The Electric Power Research Institute says they ran some research which was technically successful but had limited economic advantage. Why use the slurry method then, or isn't enough experience?

Dr. WHITE. The slurry method is just a quick fix to get a little bit of coal into use to replace oil where you can use a low or medium sulfur coal in small amounts in a boiler fired now by oil without exceeding sulfur standards. It is not technically very difficult. You have to mix it and usually add an emulsifying agent to keep it in suspension, but that is about it. We have a demonstration of this at Pittsburgh where we are running our own little boiler.

We have a few contracts to show it can be done. I believe there are six contracts. The purpose is to infuse some of the simple technology into the system.

Talking about moving out, I think we are trying to move out with the easy ones here that can go commercial in a few years.

Mr. YATES. Something you can point to with pride.

Dr. WHITE. Yes.

Mr. FRI. Something you can point to that works.

ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY

Mr. YATES. Let's talk about advanced research and supporting technology.

What processes have advanced from this area into your larger scale programs? Any?

Dr. WHITE. Catalytic gasification is started. Our first funding came in the Advanced Research and Supporting Technology subprogram for that process. Another one that is right on the verge is a process that goes from coal to methanol to produce 93 octane gasoline.

The overall economics are quite attractive. It is about ready to go into a pilot plant.

Mr. YATES. I don't know whether this constitutes advanced research and supporting technology, but are you talking about methane? It takes my mind back to when Mr. Obey was a member of the subcommittee and talking about all the waste and the methane that was going to be used from all over the country. It that conservation or advanced research?

Dr. WHITE. That is conservation.

Mr. FRI. That is solar.

Mr. YATES. You are kidding.

Dr. WHITE. No. It is in our solar program.

Mr. YATES. It is not advanced research. All right.

MAGNETOHYDRODYNAMICS (MHD)

Now, let's turn to magnetohydrodynamics, MHD, which received its emphasis originally because it was said the Soviets were ahead of us, but the Soviets are working from natural gas. Can they turn from natural gas to coal with their present technology that easily?

Dr. WHITE. I don't think they could turn that easily but they could certainly test some aspects of it.

COMPONENT DEVELOPMENT AND INTEGRATION FACILITY

Mr. YATES. You have $4.2 million for the construction of the CDIF in Montana?

Dr. WHITE. Yes; this will wind up the first construction phase.

Mr. YATES. Congressman Whitten has asked that a statement by Senator Stennis be placed in the record at this point and that may be done, without objection.

[The statement of Senator Stennis follows:]

STATEMENT BY SENATOR JOHN C. STENNIS

Mr. Chairman, and members of the subcommittee, our increasing reliance upon foreign oil imports is becoming alarming. Even more distressing is that during this critical time we are not aggressively pursuing with a sense of urgency the development of technologies whereby we can become energy self-sufficient. We must act quickly to eliminate the economic and political weapons which the oil-importing foreign countries are using against us.

This we can do with coal, our Nation's most abundant fossil fuel. Through direct coal-fired magnetohydrodynamic (MHD) electrical power generation we can utilize our vast coal resources to generate electricity in an environmentally acceptable manner and at efficiencies higher than those of any other advanced coal-fired system presently known. We must accelerate the MHD development program because it is a major energy technology which can sharply reduce our Nation's drastic dependence on imported oil.

During 1976 the United States paid $34.2 billion to foreign countries for imported petroleum products—$9.4 billion more than in 1975.

The MHD Division of the Energy Research and Development Administration (ERDA) requested $86 million for fiscal year 1978. However, OMB authorized only $50.5 million. It is inconceivable to me that we would pay $34.2 billion to the OPEC cartel and other foreign countries and yet not fund our Nation's energy-development programs at a level whereby the United States can become energy self-sufficient in the shortest possible time.

The full $86 million is essential for MHD engineering development, which requires both large-scale performance evaluation of MHD components and laboratory-scale determination of engineering design data for MHD components yet to be developed. Without this level of funding, important large-scale MHD

programs such as air preheater tests in the MHD component development and integration facility at Butte, Mont., will be postponed; pilot plant scale MHD channel high performance demonstration experiments at Arnold Engineering Development Center will be delayed; and the ERDA MHD facility at the University of Tennessee Space Institute will not be completed on schedule, nor will a required superconducting magnet for that facility be obtained. If the $86 million is not authorized, basic MHD engineering design data, such as that which is being obtained by laboratory-scale testing and evaluation of MHD materials and substructures at Mississippi State University, cannot be developed as rapidly as is possible.

The operational characteristics of the direct coal-fired MHD electrical power system downstream steam plant components, particularly the radiant boiler, the superheater and the reheater, have not been experimentally investigated under the adverse high temperature, seed/slag laden MHD gas stream environment.

Mississippi State University has constructed, under ERDA contract, a minicomputer controlled and monitored metallic materials/component test stand (MM/CTS) for simulation of the MHD slag-seed-gas conditions to allow evaluation of such MHD subsystems. That facility provides a versatile test stand for evaluation of MHD materials and subsystems over a wide range of conditions. The MM/CTS allows low-cost, precision-controlled, and rapid-performance evaluation of MHD materials and components on a laboratory scale under the various dynamic conditions of the baseline MHD plant. The operational environments and conditions to be expected at various locations in the MHD system can be determined with this ERDA MHD laboratory-scale facility. Experimental results obtained with the ERDA MHD facility as Mississippi State University will provide critical information required for the engineering design for full-scale MHD subsystems.

In my judgment it is imperative that, because of their tremendous potential toward national energy independence, both the large-scale MHD engineering testing programs and the associated laboratory-scale development programs, such as that being conducted at Mississippi State University, proceed at the rate demanded by this Nation's paramount energy requirements. I therefore believe it in the National interest, and do strongly urge that the subcommittee recommend authorization of the full $86 million to expedite the rapid development of MHD.

Mr. YATES. Are there any slippages in your schedule for CDIF?

Dr. WHITE. Thus far I believe we are pretty well on schedule.

Dr. Jackson, are we pretty happy with that?

Dr. JACKSON. We had some tentative schedules in the early days which were not made a formal part of our program planning and those were based on the availability of funds which had not been appropriated. Since the funds have been appropriated, we have kept a schedule and there have been no significant slippages.

Mr. DUNCAN. What is your schedule now?

Dr. JACKSON. The schedule calls for the facility to be complete and operable in the second quarter of fiscal year 1979—that is the beginning of calendar 1979—and to go through the shakedown procedure and to begin to provide test data in the latter part of 1979.

Mr. DUNCAN. Is that the Montana facility we are talking about?

Dr. JACKSON. The Montana facility identified as the CDIF.

Mr. DUNCAN. What about your entire MHD program?

Mr. MCKAY. It is not entirely situated in Montana.

Dr. WHITE. The Montana Component Development and Integration Facility is the center to which other component developmental efforts are feeding in. We are developing them in Tennessee, or AVCO in Massachusetts. When a component is developed at either these or some other location, it will then be taken to Montana and put into the test facility and tried out. That is the general approach.

Mr. DUNCAN. That will be ready to go by 1979 you say?

Dr. JACKSON. Yes; the AVCO MHD hardware will in fact be delivered early in 1979, during the first weeks of 1979, to the CDIF site in Butte.

Mr. DUNCAN. What about your entire program in getting demonstration plants in shape and getting it into the industrial mainstream?

Dr. WHITE. I think we have to realistically consider that that is going to be somewhere in the late 1980's at the very earliest because this CDIF facility, as Dr. Jackson said, is going to have to be followed by a carefully engineered pilot plant or engineering test facility, as it is referred to in this program. This facility would probably be built in the early 1980's, using the components which look as though they will work from the CDIF. It will have to be built and demonstrated before anybody can build a commercial MHD unit for a utility.

It is a very difficult technology to operate.

ENGINEERING TEST FACILITY

Mr. DUNCAN. But assuming that test facility, then you project a test facility in the middle 1980's now?

Dr. JACKSON. Yes.

The precise date depends on technical success and how our budget develops, of course. The mid 1980's is the proper time.

Mr. YATES. What do you mean by how your budget develops? Your budget has been developing very well. You want more budget?

Dr. JACKSON. The test facility involves two major aspects, Mr. Chairman. One is the MHD components, developed by companies like AVCO. The other is what we refer to as the balance of plant, the large expensive engineering hardware, the boilers, air heaters, and so on, and those are all scheduled in the future. The time which they become available is critical to scheduling such a facility.

Mr. YATES. How much money is involved in those?

Dr. JACKSON. Our estimate, and it is a preliminary one, is that the ETF, that is, the engineering test facility, will cost $2,000 per kilowatt capacity. It is a $200 million facility of which considerably more than half is balance of plant hardware.

Mr. YATES. This is going to be constructed in Montana?

Dr. JACKSON. Yes, in Montana.

Mr. DUNCAN. Is there doubt in ERDA's mind as to the desirability of going ahead with this component test facility and the engineering test facility with respect to MHD?

Dr. WHITE. No.

MHD DEVELOPMENT AND ADVANTAGES

Mr. DUNCAN. The concept appears to be fruitful enough that you intend to press it diligently.

Dr. WHITE. I am not sure you were here yesterday, Mr. Duncan, when I mentioned the view I was coming around to in terms of the best available technology, but just as we have legislated the best available technology to protect our atmosphere and environment, it seems to me we should come to the point of viewing the need to do that in our use of our natural resources, and anything that increases the efficiency of converting coal or any other fuel to available power is of that nature.

By requiring ourselves to do that, we will certainly help future generations, and MHD is one of the most promising technologies to do this.

Mr. DUNCAN. Am I correct that this offers about a third greater advantage? Isn't that correct?

Dr. WHITE. Theoretically even 50 percent greater, but that is probably out of reach presently.

Mr. DUNCAN. But at the same time doesn't it also represent the best available technology from the standpoint of pollutants too?

Dr. WHITE. It has the fortunate characteristic of enabling you to get rid of the sulfur by means of the seed that is put in with the coal to create the plasma. To make the cycle work you have to handle the seed and, therefore, you get the advantage of sulfur removal as part of the process. Nitrogen oxides characteristically are low because of the staged heating and cooling as you go through the MHD system so it also has that feature, not that there is any magic. Those things could be built into other high temperature combustion process by going through these same steps, but you have to do them in MHD, so you get the benefits.

Mr. DUNCAN. And you get the increased efficiency so you pay for it really with the increased electrical production you get. It has been suggested to me that in order to get your demonstration plant—is that what you call your engineering test facility?

Dr. WHITE. That would be a sort of demonstration, a big pilot plant.

Mr. DUNCAN [continuing]. By the mid 1980's you are not financed adequately. Did you ask the Office of Management and Budget for more money for this program?

Dr. WHITE. The original request was $86 million for 1978.

Mr. DUNCAN. And they allowed you what? Forty-six million dollars?

Dr. WHITE. $46 million in operating expenses.

Mr. DUNCAN. So they cut you about in half.

Dr. WHITE. $45.8 million is the figure.

MHD PROGRAM SCHEDULE

Mr. DUNCAN. Was your original request based upon an acceleration of your program?

Dr. WHITE. Well, we are getting into the very expensive part of the CDIF construction and the components, and the funds are needed to bring the components along at an optimum clip.

Mr. DUNCAN. What is the CDIF?

Dr. WHITE. Component Development and Integration Facility. That is the one in Montana.

We are trying to keep the components that feed into that all on a fast track.

Mr. DUNCAN. Did I detect in the testimony of Dr. Jackson that your present financing is bringing you the magnetohydrodynamics hardware in that project schedule but there is still some doubt about the balance of your plant hardware? Is that correct?

Dr. JACKSON. That is basically correct.

Mr. DUNCAN. It doesn't do us any good to have all of this MHD stuff out there if we don't have the boilers and balance of plant to go with it.

Dr. WHITE. There is going to be a definite slippage if we don't have the balance of plant.

Mr. DUNCAN. I assume then your request for $86 million was predicated upon a time schedule of bringing all of this hardware along simultaneously so that you would be able to get that thing going in 1979?

Dr. WHITE. That was the basis.

Mr. DUNCAN. And then I want your statement as to whether or not at $46 million you are going to be able to do this. That is why I was asking you about your schedules. You gave me schedules of 1979 for your component test facility and the early 1980's for your engineering test facility, but at this budget level there is going to be some slippage. How much slippage?

Dr. WHITE. At least a year or probably two.

Mr. YATES. Slippage in test or components?

Mr. DUNCAN. The component test and the engineering will both slip a couple of years, is that correct?

Dr. WHITE. Let me explain a little bit why it may have looked a little misleading. The thing that is on schedule is the buildings and the framework in which to put this, which was the first major contract. However, of the components that are going to go in their initially, some are going to be on schedule but others are going to be slipping, and I think we have to recognize that the whole program will slip down the line.

Mr. DUNCAN. So if this is true you won't be getting the components for the building completed on schedule it is really going to be kind of a Pyrrhic victory because you won't be able to use it.

Dr. WHITE. We will get some use, but surely not the optimum use.

Mr. DUNCAN. Are you aiming for commercial utilization of this process by any target date assuming that your experiments work out?

Dr. WHITE. Our original schedule, which I guess we would have to agree now is probably optimistic, was, I believe, commercialization by 1990 or even the late 1980's.

Mr. DUNCAN. About 1990. But if your financing is at this level you are not going to make it, are you?

Dr. WHITE. It is certainly a substantially reduced chance that we will make it.

POTENTIAL FOR MHD

Mr. DUNCAN. What is the potential fate of this process, as promising as it looks now, for commercializing it in the early 1990's? With all these other marvelous experiments you have going we won't even be interested in it, will we, at that time?

Dr. WHITE It has the potential of raising efficiency by the amount I mentioned earlier. The combined cycle, advanced power work, which is also long term and will be available in the late 1980's, is in the same direction of improving efficiency, but would be unlikely to get the one-third improvement expected from MHD. You might get 20 percent.

Mr. DUNCAN. We are going to be getting all kinds of energy from the sun, aren't we, with fluctuating heated molecular action?

Dr. WHITE. Not much at night.
Mr. DUNCAN. I will yield.

EXPLORATION OF MHD PROCESS

Mr. REGULA. Dr. White, would you explain this process in layman's terms? What do you hope to gain from it? In other words, as I understand it you will convert more Btu's to power. Exactly how does it work?

Dr. WHITE When you start out, instead of taking coal and burning it with air directly in a boiler, you use very highly preheated air or air enriched with oxygen to get a very high temperature, up in the 4,500 to 5,000 degree range. You then add to that a very hot gas mixture which now has ash from the coal in a molten state, the slag, a certain amount of salt, potassium or cesium salt which immediately is ionized. Now you have positive and negative ions. The hot gas flows through a channel of several meters of length, yards long, and in a demonstration plant perhaps a yard in each cross sectional division. The walls consist of electrodes, a series of them, which are positive and negative electrodes, and the electrons and ions actually move toward the negative and positive electrodes respectively because they are under a very high magnetic field and behave like charged particles moving through a magnetic field.

You can then draw off that current because these charged particles precipitate that charge. You can draw off perhaps 20 percent of the energy that is potentially in the hot plasma as electrical energy. Then you collect the slag and seed; and try to recycle the seed, which is one of the unsolved problems.

You then go into a regular boiler because you still have a very hot gas, and you generate steam. That steam part is what you would normally get, but you have added to it this electrical drawoff earlier and if you want to get really fancy you can put a gas turbine in there and catch more power as you go through.

Mr. REGULA. The reason you have to do this and not the utility industry is that it is not economically atractive to the private sector at this point. Is that correct?

Dr. WHITE. The materials requirements for the electrodes, the slag handling, and the combustor in which you burn coal are so exotic and really outside of the present state of the art that people simply don't know how to design such components. It has been proven in the laboratory that MHD will work. It is not like fusion, which still has to be demonstrated technically. There is no question that it does work. The engineering, however, is a very challenging problem.

Mr. REGULA. Does the content of the coal make a difference in this process?

Dr. WHITE. Yes; it will because it will affect the chemical nature of the slag and the electrical conductivity of the slag.

Mr. REGULA. Is it designed for high sulfur coal or low sulfur coal?

Dr. WHITE. I had better defer to Dr. Jackson.

Dr. JACKSON. The kind of coal does not significantly affect the conductivity because of the properties Dr. White referred to earlier. There are some differences between eastern and western coal and in coal in other parts of the world, but these are well within the limits

of the system. This is not a critical parameter. The detailed properties of the slag and their effects on materials are much more important.

Mr. DUNCAN. Is this innovation process similar to this chap who is going to create electricity from sunlight by fluctuation energy resulting from thermal motion of electrons? Is ionization and thermal motion of electrons the same?

Dr. WHITE. I don't think there is much similarity. I don't know the answer to that. I don't think so.

Mr. FRI. It is more of a semiconductor kind of application.

Mr. DUNCAN. But you are drawing electricity directly out of the product of the combustion of the coal without it passing through a turbine, aren't you?

Dr. WHITE. Yes, sir, but you have to have the seed there because that really gives you this large production of electrons and ions from the easily ionized seed material.

Mr. DUNCAN. The commercialization of this appears to be 20 years off, doesn't it, roughly?

Dr. WHITE. Fifteen at a minimum.

Mr. YATES. It depends upon whether you buy them their boilers.

Mr. DUNCAN. Depending on the rate of financing.

Dr. WHITE. There is no amount of money you could give us that would put this in a 5-year timeframe.

OTHER TECHNOLOGIES

Mr. DUNCAN. But we continue to keep under test for commercial use in the early 1990's. But you still had this question as to what the state of the energy picture would be like and whether we won't at that time reasonably expect from solar or biomass or whatever. You are talking about energy in such masses that this would represent wasted effort.

Dr. WHITE. The only alternative electrical power generation system you could see doing this would seem to me to result from an acceleration of the breeder. An alternative breeder cycle such as Mr. Fri was talking about yesterday, could be acceptable to the world, or fusion. In fusion really you have a complete breakthrough. If we learned how to do fusion successfully from an engineering viewpoint, that would change the picture.

Mr. DUNCAN. Sometime today will you have somebody here who can tell me about this hearing they had in the Government Operations Committee last June on the direct conversion of solar energy into electricity? I mentioned it to you last night, Mr. Fri. It may not be an appropriate spot to discuss it, but if this committee hearing is correct, then I think we have to take a look at all of these long-range extremely expensive technologies.

MHD, COMBINED CYCLE AND FUEL CELLS

Mr. FRI. May I say one thing on this? Dr. White made the point yesterday and again today which I think is extremely important. There are probably three technologies which can operate at very high efficiency in the use of coal. These are MHD, the combined cycle technology, and the molten carbonate fuel cell. It is important not only that

each be kept to an optimal schedule but that they not get drastically out of sync with one another, because at some point it may be necessary to compare them and make a tradeoff among them. We may decide we like all three, or we may decide that one is a clear winner. I would suspect that that decision is 5 to 7 years away.

Mr. DUNCAN. Give me those three again.

Mr. YATES. Molten carbonate fuel cells, combined cycle and MHD. What else would you like to know?

Mr. DUNCAN. Do you have the same slippage in these other two programs as you do in the magnetohydronamics?

Dr. WHITE. I can't speak to the fuel cells, but advanced cycle work is not slipping as yet.

Mr. DUNCAN. Are we correct in assuming that you wouldn't have gone to Mr. Lance if you hadn't thought you needed $86 million for this in order to keep it parallel with these other two technologies and in order to approach commercialization by the early 1990's? That would be a fair statement? You are nodding you head in the affirmative.

Mr. WHITE. Yes, sir.

Mr. REGULA. Will the gentleman yield?

Isn't there an element that it is incumbent on the agency to say this is the optimum, without regard to the other dimensions of the budget, whereas OMB has to say that may be optimum? You can get your house paid for in 5 years instead of 10 if you decide not to eat.

Mr. DUNCAN. I think that is right.

Mr. REGULA. They are saying, look, in relationship to the total this makes sense at 40 years or whatever level they have agreed to—is that part of the thinking?

Dr. WHITE. Yes, trade-offs have to be made. This is a trade-off. It is a long-term technology. It will not solve 1980's problems. One of the things we are looking at are 1985's problems, on a commercial basis. One of the things that motivates OMB clearly is to be sure that funding is on schedule for those items which will affect 1985, and that is a judgment that they made. We are really answering these questions as brought out in the context of this program's optimum base.

Mr. DUNCAN. What you are saying is that the Office of Management and Budget is viewing this as a solution to the late 1990's or early 2000 problems.

Mr. WHITE. Yes.

Mr. DUNCAN. And you commended the program with a view to solving the early 1990 problem, is that correct?

Mr. WHITE. Yes. We never saw it as any near-term solution.

Mr. DUNCAN. I would like a statement in the record, if you can't give it now, because of what Mr. Fri said, about paralleling these three high technology programs, as to whether we are still paralleling with the reduced budget, the Office of Management and Budget authorized you to come down and ask for, as opposed to your $86 million.

Dr. WHITE. I think, Mr. Duncan, I would have to say that I think it would take a good deal more analytical study of these three programs comparing them with each other and their milestones for decisions than we have given to date. This is a request Mr. Fri made for the first time a few days ago. It is obviously one we should have within a few months, but I wouldn't want to try to put it in the record for this hearing.

Mr. DUNCAN. With respect to the other two programs, will you insert in the record what you asked the Office of Management and Budget for, and then for my convenience in seeing them in juxtaposition, the amount of the budget request.

Dr. WHITE. We certainly can do that.

Mr. YATES. Let me interrupt a moment. Aren't you kind of reborn again on this magnetohydronamics? You didn't ask the Lance people for more money, did you? As I understand it, your initial amended budget request was not more money for magnetohydronamics.

Dr. WHITE. The focus that we were given, as I understand it, was to come in with things that would be critical to the near term.

Mr. YATES. That is right.

Dr. WHITE. And we didn't consider MHD critical to the near term and, therefore, did not ask for money.

Mr. YATES. Now we have Dr. Schlesinger's being reborn again on the long-term, is that right?

Mr. FRI. Not yet.

Mr. YATES. Not yet?

Mr. FRI. Not yet. We are working on that.

FUEL CELLS

Mr. YATES. Except that you did come in with requests for more money of the newly born Lance OMB for fuel cells. At the time you came in for more money for fuel cells, you did not come in for more money for magnetohydronamics.

Mr. FRI. These are current generation fuel cells with nearer-term applications.

Mr. YATES. These are current generation fuel cells.

Mr. FRI. Yes.

Mr. YATES. Is there a difference?

Mr. FRI. Yes.

Mr. YATES. Tell us what the difference is.

Mr. FRI. Basically, the current generation uses natural gas which doesn't require the gasification of coal, and could therefore be more efficient in the use of present day resources. Let me let Dr. Mannella explain that.

COMMERCIALIZATION PLAN FOR FUEL CELLS

Dr. MANNELLA. Thank you, Mr. Chairman.

Our whole game plan or commercialization plan for fuel cells goes something like this. We have what Mr. Fri refers to as first generation technology. This is a phosphoric acid electrolyte fuel cell which has been under development and which is very close to completion for electric utilities to use as peaking and load levelers.

Mr. YATES. Is this the kind of fuel cell for which we added funds at the end of last year?

Dr. MANNELLA. That is correct.

Mr. YATES. That is the near term fuel cell?

Dr. MANNELLA. This is the near term fuel cell that would hopefully replace some of the gas turbines that are used for peaking.

Mr. YATES. I see.

Dr. MANNELLA. It would operate at about 40 percent efficiency, as opposed to say 22 percent for gas turbines. But it would also introduce the utilities to using this kind of machine for electric power generation. If we are successful with the goals that we have established for the phosphoric acid fuel cell, that is $300 per installed kilowatt and a 5 percent degradation in performance over 5 years, about 50 units in the 26 megawatt range will be ordered.

Now, beyond this first generation technology, which we are putting the bulk of our resources in, to get them into the actual utility use, we have been doing technology development work on another type of electrolyte, a molten carbonate type of electrolyte.

This type of fuel cell would have as its mission not peaking but intermediate and base load, and the scale is such that it is very attractive to integrate it with a coal gasifier. It would be economically attractive for this scale of electrical generation to integrate it with a coal gasifier.

We are talking about efficiencies from coal pile to bus bar in the range of 55 percent, which compares to something like 33 percent for conventional coal fired generating plants today.

MHD VS FUEL CELL EFFICIENCY

Mr. YATES. It is the equivalent of magnetohydrodynamics then?

Dr. MANNELLA. It is very, very competitive in the efficiency range, and it is certainly competitive in the economics and other aspects.

HIGH-PRIORITY ENERGY TECHNOLOGIES

Mr. YATES. Let's stop a minute and think. We have the three highly sophisticated technologies, apparently on which we are banking our future energy progress, aren't we?

Mr. FRI. We are banking on these three which have been extensively evaluated over the past couple of years. All the operations have been evaluated. These three come out as being the most attractive for getting higher efficiencies in the use of coal for power production. That is what it boils down to.

Mr. YATES. OK. We find that magnetohydronamics has enjoyed a very spirited acceleration of its programing, haven't we?

Mr. FRI. Yes.

Mr. YATES. And a great deal of money poured into it. Now, have the other two enjoyed that same kind of activity?

Mr. FRI. Not really.

Mr. YATES. Not really, OK. And they are not as important as magnetohydronamics?

Mr. FRI. The three technologies at this stage of the game have to be regarded as equally important.

Mr. YATES. Did you ask OMB for the same amounts for each of them?

Mr. FRI. No, but one of the things that is important to understand is that these are somewhat more evolutionary technologies.

Mr. YATES. You mean MHD is more advanced?

Mr. FRI. MHD is more of a ground up kind of technology. We have operating fuel cells, and the problem in the molten carbonate fuel cell is to use the new electrolyte, and to link it up to a coal gasification plant. We don't have to develop a whole coal gasification program for the molten carbonate fuel cell program. Similarly, combined cycle depends a lot on other technologies being supported within ERDA, such as gas cleanup and the like.

We are working on those aspects in other parts of the program. MHD is basically a whole different track. The component parts you need for MHD are not also being developed in other program areas.

Mr. YATES. Will you require much more money for MHD than you will for the other two?

Mr. FRI. I don't know what the total program cost.

Mr. YATES. Who would know that? Apparently we know something about where we are going in MHD. We know that we have to have your CDIF facility, and then you are going to have your additional buildings and the boilers.

Mr. FRI. Yes.

Mr. YATES. Apparently that has been thought out and laid out in a financing program. Now, has the same thing been done for fuel cells?

Mr. FRI. I will ask Dr. White to speak to combined cycle and Dr. Mannella to speak to the molten carbonate fuel cell.

Mr. YATES. The thing that troubles me somewhat is that MHD seems to be the darling of ERDA at the moment in terms of your programing and in terms of your potential expenditures, and I don't get that same impression with respect to fuel cells or combined cycle. Is my impression wrong?

Dr. WHITE. I guess I have to say we have been probably given more attention to MHD than we have to the combined cycle.

Mr. YATES. Why haven't you given as much to combined cycle?

Dr. WHITE. For one thing, it actually doesn't have quite the potential. We take the peak of these increased efficiencies.

Mr. YATES. You are talking about fuel cells?

Dr. WHITE. Fifty-five percent for fuel cells or MHD but with combined cycle, if we get to the high 40's we will be doing well. You don't have quite as juicy a carrot to work toward.

Mr. YATES. So that it becomes less attractive than the other two is what you are saying?

Dr. WHITE. Somewhat less attractive although the economics may be a little easier. It is still tough but it may not be quite as tough as MHD.

FUNDING REQUIREMENTS

Mr. YATES. How much is MHD going to cost you before you perfect it?

Dr. WHITE. In the development cost?

Mr. YATES. Yes.

Dr. WHITE. I think we are probably looking at $500 million.

Mr. YATES. How much will combined cycle cost you?

Dr. WHITE. I think I had better defer on that.

Dr. NEUWORTH. I think the components of the combined cycle in gasification are receiving considerable emphasis, about $25 million a year, for 3 or 4 years. You develop readiness to build the turbine.

When you start building them, you will be talking about several hundred million dollars.

Dr. WHITE. Certainly several hundred million. I think 3 or 4.

Mr. YATES. Why aren't you giving it the same attention you are giving to MHD?

Dr. NEUWORTH. It isn't being treated as an integrated technology. It is being supported in several segments which will be combined.

Mr. YATES. That raises the question in my mind, should you be treating it as an integrated technology?

Dr. NEUWORTH. The way it should be developed in contrast to the MHD?

Mr. YATES. Are you doing what you should be doing is what I am asking. Are all these three technologies yours, Dr. Neuworth?

Dr. NEUWORTH. No.

Dr. MANNELLA. The fuel cells are in the conservation program.

Mr. YATES. Dr. Neuworth, let's go back to the cycles. Are we doing as much there? Obviously we are not doing as much in that program as we are in MHD, are we?

Dr. NEUWORTH. No.

Mr. YATES. Should we be doing as much?

Dr. NEUWORTH. I think we asked for more money in the advanced turbine area, which was also reduced for technology development.

Mr. YATES. Are you on the same kind of a coherent integrated schedule?

Dr. NEUWORTH. Yes; I think we are.

Mr. YATES. With your cycle program, as you are with MHD?

Dr. NEUWORTH. I can't speak for MHD, but I think we are on a coherent schedule.

Mr. YATES. You don't want any additional help on your cycle program?

Dr. NEUWORTH. I think we asked for additional money in 1978.

Mr. YATES. How much more did you ask for?

Dr. WHITE. We asked for $38.8 million and we were given only $25.5 million.

Mr. YATES. You asked for how much?

Dr. WHITE. $38.8 million.

Mr. YATES. So there is a difference of $13 million?

Dr. NEUWORTH. For advanced turbines.

Mr. MCKAY. That is only part of the cycle.

Dr. WHITE. There is cleanup.

Mr. YATES. Then there is no comparison in the expense of the programs.

Dr. NEUWORTH. Components of the program are being developed in parallel, and the technology readiness program requires the development of new components, and the indication was that this is a level of effort that we felt would satisfy the need.

Mr. YATES. When we get to conservation, we will join the fuel cells into the comparison.

MHD HARDWARE SCHEDULE

Mr. DUNCAN. I have one more question, Mr. Chairman, on the magnetohydrodynamics. If we have made a decision to defer the

ultimate commercialization of this by cutting back on our purchase of the plant hardware, shouldn't we then make a parallel in the acquisition of the MHD hardware? It doesn't seem to me there is any point having one bunch of stuff sitting in crates there if we can't use them.

Dr. WHITE. This is the point Mr. Fri asked us to work out more thoroughly, to be sure we have got these tracked so they are all on an optimum and equally accelerated track, these three competing technologies. We really aren't there yet.

RELATIVE IMPORTANCE OF THE THREE TECHNOLOGIES

Mr. YATES. Why don't we do this, if you will permit me to interrupt for a moment. We are going to adjourn until 1 o'clock. Maybe I have the wrong impression but as I indicated before, you have these three sophisticated technologies. You are banking a great deal on them in terms of our solving our energy problems. What we are trying to do in this committee is find out where the funding is for all three of these programs.

The first question is, are they of equal importance. If they are of equal importance, should they be treated equally and should the funding be equal in terms of how we progress. Can you tell us that at 1 o'clock?

Mr. FRI. We will try. Let me just make one brief background statement. Over the course of the last couple of years, there has been a study called ECAS going on—energy conversion alternatives study—which has looked at all of these kinds of technologies, MHD, open cycle, combined cycle, closed cycle, metallic topping cycle, and so forth, to figure out which are the ones that are likely to be the most efficient and economical and feasible to develop.

Those results are in and we have analyzed them. As a result of these studies, we are coming to the view that the three technologies we have identified are the ones that are most promising for the future for the highly efficient combustion of coal.

Now, having come to that view fairly recently, we haven't yet completed the detailed program integration job of making sure that we have all the schedules tracking one another, but we will try at 1 o'clock to give you the best information we have.

In the meantime, I think we probably had a little more help on MHD than we have on these other two technologies.

Mr. YATES. I am sure you have, but what I am trying to tell you is that perhaps you can get additional help on the other two programs as well.

Mr. FRI. I understand.

Mr. YATES. And you will let us know the answers to that, but I wish you would also put into the record the state of the development of MHD at not only Montana but Massachusetts, Tennessee, and Mississippi, an overall statement on what is happening there, and the time frame. What are the most critical items of development and the time frame you need and the funding you need for achieving the time frame.

[The information follows:]

What is the current state of development of MHD? Identify the critical items of MHD development along with the related time frames.

1. Status

Open-cycle MHD has now advanced from the stage of exploratory investigation, conducted primarily by investigators working independently, to engineering development in which the program is structured to achieve the objective of design, construction and operation of a commercial scale MHD power plant which will generate electricity directly from coal or a coal derived fuel. The high efficiencies and environmental acceptability that are achievable with MHD systems make MHD competitive with other power sources, result in the conservation of limited resources, and improve power plant systems economics. By burning less fuel to produce the same amount of electricity, fossil and other fuel resources can be conserved and their lifetime extended. Economic studies of the various MHD systems have shown very large potential savings in total power costs and MHD has built-in features which enable it to meet existing environmental standards without additional control technology.

2. Development Approach

The development of MHD involves a resolution of many issues concerned with both the components and the overall system. The four critical paths which must be followed in parallel are:

1. The MHD channel itself. This has to be developed to the point where its performance both in terms of electrical efficiency and duration are adequately demonstrated for the conditions of central station power generation;

2. The coal combustor much achieve the temperatures and pressure appropriate for efficient generator operation on the combustion of coal with preheated air. It must also deliver the required plasma properties;

3. Integration of the MHD components - combustor, nozzle, channel, diffuser, superconducting magnet, power conditioning equipment (inverters) and high temperature air heaters;

4. Integration of the MHD components (hot gas flow train) into a complete electrical power generation system involving the MHD process.

Research and development efforts in MHD have thus far concentrated on the MHD generator channel itself and the only other component which is receiving funding for engineering development is the coal combustor. Small-scale and preliminary engineering is also being undertaken on air heaters, coal injectors and seed injection-recovery systems (seed-slag management) and design of steam generators. The first superconducting magnet is approaching completion and some laboratory experiments have been undertaken with inverters. The size 20-50 megawatts thermal (2-6 tons of coal per hour) is the minimum at which it is possible to scale-up to a pilot plant or Engineering Test Facility (ETF).

At present, all component research and development work is in the 8 thermal megawatts or less range though one channel project is being conducted at 20 megawatts thermal and design work on coal combustors in the 20-50 megawatts range has recently been initiated.

3. Important Results

Important results from the preliminary engineering phase have included successful MHD generator operation for 100 hours with moderate slag carryover (1976), improved recovery of seed and slag from the gas stream (1976), identification of promising materials for direct fired preheater application (1975-6), and progress in preheater durability demonstrated (1976) by more than 400 hour run on a tandem configuration in which temperatures achieved were in excess of 3000°F all demonstrate tangible progress in (1) generator durability and performance under slagging conditions, (2) development of requisite seed/slag recovery and separation techniques, (3) development of direct fired preheaters required for the highest plant efficiencies, and (4) preheater durability and system operations and control. In addition, the demonstration of MHD generator performance from the point of view of turbine efficiency and enthalphy extraction are of major importance to the successful application of the MHD process. Using a shock tube facility with a thermal power of about 100 megawatts, a disk type generator has recently been tested (April 1977) and has achieved almost 11% enthalphy extraction.

4. Results Obtained in the USSR

In 1963, the Soviet Union established a pilot plant program with the objective of developing MHD for operation with natural gas. The design of this pilot plant was completed in 1967 and it has been operated for several thousand hours since initiation of test operations in 1971. Two major technology milestones were established

and both have now been achieved. They are:

1. Operation in eccess of 20 megawatts of electrical output for 30 minutes (December 1975).

2. Continuous operation for 250 hours at a power level in eccess of 10 megawatts (April 1977).

While there are detailed differences with respect to the MHD generator between gas and coal fired, these results together verify the viability of the MHD process on the pilot scale.

5. Component Development and Integration

Engineering scale work is needed on superconducting magnets, air heaters, inverters, seed and slag systems, steam generators and pollution control systems. In addition, essentially no work has been attempted in the integration of these components into critical subsystems and on the instrumentation and control systems needed in the ETF scale and larger installations.

The MHD Division has developed an integrated program to carry forward all component development efforts, and is proceeding to implement it within the capability of existing facilities, modification of these facilities where appropriate and the funding constraints of the program. The component development and integration schedule for the Butte, Montana, Component Development and Integration Facility (CDIF) currently involves the design, construction, and delivery to Butte of a coal fired combustor (Pittsburgh Energy Research Center), an ash injection combustor (currently in procurement), MHD generator channels to operate with these combustors (AVCO Everett Research Laboratory, Inc.), conventional and superconducting magnets (currently in procurement), and special components required for integrating these MHD components. This first group of test components can be assembled into two test trains to obtain critically needed data. Construction of this facility will be completed in the beginning of 1979 (2nd Quarter of FY79) and shakedown and the acquisition of experimental data will be conducted in the 1979-80 period.

In addition to the role of the CDIF in providing design data for an MHD pilot plant, other program activities contribute to this work. These include the AVCO Mark VI facility at Everett, Massachusetts; existing facilities at the University of Tennessee Space Institute; Pittsburgh Energy Research Center; Reynolds Metal Company, Alabama;

and the Arnold Engineering Development Center, Tullahoma, Tennessee. Facilities for air heater work exist at the General Electric Company, Valley Forge, Pennsylvania, and Fluidyne Corporation, Minneapolis, Minnesota. Smaller-scale test rigs are also set up at Stanford University, Westinghouse Research Laboratory, and the Massachusetts Institute of Technology, and test facilities in the 10-20 thermal megawatts range are under construction by the Westinghouse Corporation and the University of Tennessee Space Institute. All of these have the potential to provide data for pilot plant design and to undertake the engineering scale work needed in the MHD program during the 1978-81 time frame.

Of particular importance is the conversion of the former LORHO generator facility at the Arnold Engineering Development Center to be a test facility for pilot scale MHD channels. The MHD Division considers it of critical importance to test ETF scale channels in advance of designing the Engineering Test Facility and so avoid the problems adherent in combining integrated facility operation with the proving out of the most critical component - the MHD generator channel itself. This facility is also expected to provide data in the 1979-80 period.

6. Engineering Test Facility (Pilot Plant)

The main objective of the MHD program is the design and construction of a pilot scale Engineering Test Facility (ETF) which can be operated by the mid-1980's. The ETF, which will be a complete MHD/steam combines cycle system fired with coal will have the first complete demonstration of the MHD process in the United States. It is expected to provide an electrical power output of about 100 megawatts and as such to constitute a large pilot plant. Conceptual design studies were begun in January 1977, and the schedule, based on the current FY78 budget request, projects the beginning of Title I Preliminary Design in the beginning of FY82 with start-up of operation in late 1986.

7. Reference

We are providing the Committee a more detailed account of the status of MHD contained in the attached copy of "MHD Electrical Power Generation - 1976 Status Report".

89-805 O - 77 - 36

Mr. YATES. We will come back at 1 o'clock.

AFTERNOON SESSION

COMBINED CYCLE PROGRAM

Mr. YATES. Are you satisfied with what you have got on the cycles and MHD?

Dr. WHITE. The original request for the combined cycle, as mentioned before lunch, was some $13 million higher.

Mr. YATES. Is that enough?

Dr. WHITE. It is very clear as we indicated in the impact statement that the lower amount is going to stretch out that program. As we were discussing during the luncheon period, each of these programs really has been developed on its own track.

It is only with the availability of the ECAS study, which is very recent, which in itself recommends that each of these programs be continued until it is clear which of them is most attractive, which may take several years, that we have begun to look at them as ones that ought to be brought together on a coordinated basis somewhat more than we have.

Whether or not we do that this year, we certainly aren't prepared to do it now, and it is a little premature to say additional funding for combined cycle would necessarily correct a mismatch on that track.

It obviously holds down combined cycle. On the other hand, combined cycle may be ahead of the others. We are just not sure at this stage. I just don't think it is. I think it is a little early to really specify and it may be more appropriate to look at this in the 1979 budget.

Mr. Greer may want to comment on that point.

Mr. GREER. What the ECAS study says is that fuel cycles could penetrate with the first plant in about 8 years, I believe.

Dr. MANNELLA. That is, be commercial.

Mr. GREER. Combined cycle will be commercial in about 12 years, and MHD possibly something in the neighborhood of 15 to 20 years. We really haven't pulled that togetther then and put a budget together, priority setting, to get a decision. The ECAS study also suggests that we ought to also continue all three on their present track for the next few years.

What we really see is this being a 1979 or later decision rather than 1978.

Mr. YATES. So the sum total of everything you want then is the $13 million for the fuel cycles. What about Dr. Mannella?

FUEL CELL FUNDING

Dr. MANNELLA. Our total request for fuel cells is $31.2 million including the fiscal year 1978 amendment Mr. Chairman.

Mr. YATES. Your total request. What did you request of OMB?

Dr. MANNELLA. I believe the request to OMB was $28 million in budget authority.

Mr. YATES. Are you ahead of the game?

Dr. MANNELLA. Yes, we are, and with the President's recent energy initiatives, $3 million is added for the development of a 40 kilowatt

fuel cell. This is included in the fiscal year 1978 amendment. The 40 kilowatt fuel cell would be used as part of a total energy system for hospitals, schools, and buildings of that sort.

Mr. GREER. The Ford budget level was less than our request to OMB. One of Dr. Schlesinger's initiatives was to restore it to the requested level, and in fact with the recent addition we will be a little bit above that initial request of last fall.

Mr. YATES. OK, everybody is happy.

PETROLEUM AND NATURAL GAS

Let's turn to petroleum and natural gas. You have heard of the GAO report, Dr. White.

Dr. WHITE. Yes.

Mr. YATES. January 28.

Dr. WHITE. Yes.

Mr. YATES. It is kind of critical, right?

Dr. WHITE. Yes.

Mr. YATES. Were their criticisms well taken?

Dr. WHITE. We didn't feel so. We felt they ignored the fact that we had well underway, and we advised them of this, a management plan of considerable depth on the whole enhanced oil recovery side, and we had started a plan for the enhanced gas recovery program.

Mr. YATES. Do you want to put your reply in the record? Have you made a reply to that?

Mr. GREER. Yes, it is included in the GAO report.

REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Improvements Needed In The Federal Enhanced Oil And Gas Recovery Research, Development, And Demonstration Program

Energy Research and Development Administration

Advanced methods to recover currently nonrecoverable oil and gas could contribute to reducing this Nation's dependence on imported energy. Commercialization of many of these techniques will require more technology development. Other obstacles--primarily economic--also stand in the way of commercialization.

The Energy Research and Development Administration has a risk-sharing cooperative demonstration program to stimulate industry commercialization of advanced recovery technologies. However, the program has not been based on adequate planning and has been moving along at a slow pace. Although the agency is attempting to improve the program, it is unlikely to have a major effect on increasing domestic oil and gas supplies before the late 1980s or early 1990s.

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-178205

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses the improvements needed in the Federal enhanced oil and gas recovery research, development, and demonstration program.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget, and to the Administrator, Energy Research and Development Administration.

Elmer B. Staats

Comptroller General
of the United States

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ABBREVIATIONS

ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
FPC	Federal Power Commission
GAO	General Accounting Office

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

IMPROVEMENTS NEEDED IN THE FEDERAL ENHANCED OIL AND GAS RECOVERY RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM
Energy Research and Development Administration

D I G E S T

About 425 billion barrels of crude oil have been discovered in the United States. However, over two-thirds of these resources (290 billion barrels) are not economically recoverable at current prices with the conventional technologies now used. Likewise more than a quadrillion cubic feet of natural gas may exist in the Rocky Mountain and Appalachia areas. This gas is not commercially producible with current extraction technology. (See p. 1.)

The Energy Research and Development Administration has an enhanced oil and gas recovery program. The term "enhanced recovery" has a distinctly different meaning for the production of oil as contrasted to the production of gas. Enhanced recovery of oil refers, for the most part, to increasing output from producing reservoirs. Enhanced gas recovery generally refers to the production of gas from areas where commercial production has not previously been possible. (See pp. 1 and 2.)

The program itself is not intended to produce large quantities of commercial oil and gas, but is supposed to stimulate industry to commercialize enhanced recovery processes by

--accelerating, through cooperative cost-sharing contracts, industry's development of enhanced recovery technologies;

--evaluating the technical and economic feasibility of enhanced recovery technologies; and

--making publicly available the results of its research and development efforts.

As of mid-September 1976, the Energy Research and Development Administration had initiated

27 oil and gas demonstration tests to assess the technical and economic feasibility of commercial-scale enhanced recovery. The total estimated cost of these tests is approximately $122 million with the Energy Research and Development Administration and private industry participants contributing about $46 million and about $76 million, respectively. (See pp. 9 and 10.)

In 1975 the Energy Research and Development Administration established goals of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes by 1985. The 1985 production goals were recently reduced to 500,000 barrels of oil a day and 3 billion cubic feet of gas a day. (See p. 11.)

Although GAO directed its review specifically at the effectiveness of the Energy Research and Development Administration's management of its enhanced recovery program, it recognizes that other factors will affect the development of enhanced recovery technologies. For example, increases in oil and gas prices could stimulate industry research and development and reduce the need for a Federal enhanced recovery research and development effort. (See pp. 13, 15, 21, and 22.)

DEMONSTRATION SCHEDULES LACK TIMELINESS

In 1975 the Energy Research and Development Administration developed a startup schedule for 103 oil recovery demonstration tests which were thought to be needed to attain the agency's 1985 oil production goals. The agency also plans 94 natural gas recovery demonstration tests to achieve its 1985 gas production goals. These oil and gas recovery demonstration tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. (See pp. 11 and 13.)

The Energy Research and Development Administration's schedules for developing enhanced

oil and gas recovery techniques are unlikely to stimulate enough industry production to reach the agency's 1985 goals because the schedules call for most tests to start during the last 3 years of the 7-year period 1974-80.

Since field demonstrations of the most promising oil recovery methods require 4 to 5 years to complete, most of the technical and economic data needed to prove the commercial feasibility of the technologies will not be available until the 1982-85 period. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests are available. Therefore, the current Energy Research and Development Administration demonstration schedule cannot be expected to result in considerable commercial oil production increases before the late 1980s or early 1990s. (See p. 12.)

Enhanced gas recovery technology is not as advanced as enhanced oil recovery technology, and the Energy Research and Development Administration's program is proceeding slowly under the current schedule. As a result, although the time between successful demonstration of enhanced gas recovery methods and substantial gas production using these methods is shorter, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s. (See pp. 13 and 15.)

LACK OF AN EFFECTIVE MANAGEMENT PLAN

The Energy Research and Development Administration has not had an effective program management plan for enhanced oil and gas recovery which would result in the most rapid and effective means for increasing domestic petroleum supplies. (See p. 17.)

Recovery methods which prove successful in one oil reservoir may not be productive in others because reservoir characteristics vary. Therefore, to show that these processes can be applied on a widespread commercial basis, demonstrations of their technical and economic

feasibility must be performed in many different types of fields. (See p. 12.)

GAO found that before attempting to implement a field demonstration oil test program, the Energy Research and Development Administration did not identify those reservoirs with the characteristics which could best demonstrate enhanced oil recovery applications. (See p. 17.)

Agency officials could not provide any documentation showing why 94 field demonstration tests of enhanced gas recovery were needed or how the scheduling was derived for these tests. The officials were uncertain of how many projects were necessary to develop enhanced gas recovery technologies. (See p. 17.)

If the Energy Research and Development Administration's oil and gas enhanced recovery program is to contribute considerably to developing these potential energy sources, a well-defined program management plan is essential. A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies. (See p. 18.)

Agency officials told GAO that, pursuant to an Office of Management and Budget request, they are now developing a management plan for the enhanced oil recovery program. In developing the plan, the agency is attempting to, among other things, identify major oil reservoirs and assess the best enhanced recovery methods to use on each and better define what the Federal role should be in achieving enhanced oil and gas recovery objectives. The agency intends to include in its program management plan:

--The priority of targets for enhanced recovery testing.

--The sequence of tests and cost.

--A system of disseminating technical information.

--A system for measuring the program's effect on production.

--A plan for assessing the environmental consequences of such a program.

Its officials also said they started developing a similar type of management plan for enhanced gas recovery in December 1976. GAO believes these are important steps for an effective enhanced oil and gas recovery program. (See pp. 18 and 19.)

FURTHER CONSTRAINTS TO COMMERCIALIZATION

Several factors are constraining industry from demonstrating and commercializing enhanced recovery technology, including:

--The lack of known long-term oil and gas prices against which to calculate economics.

--The large capital investments required.

--The unproven and risky nature of many enhanced recovery techniques.

--Uncertainty as to the future availability of needed recovery materials for the enhanced oil recovery processes. (See p. 21.)

These constraints could slow commercialization of enhanced oil and gas recovery and could interact to make the Energy Research Development Administration's revised goals of increased oil and gas production even more difficult to achieve. (See p. 24.)

RECOMMENDATIONS

GAO recommends that the Administrator of the Energy Research and Development Administration:

--Give continued and increased emphasis to developing and putting into operation a management plan for enhanced gas recovery. The plan should focus on developing a balanced research program to include laboratory research, demonstration tests, and the gathering of geological data on the types of deposits the agency plans to test. The plan should also define the number of demonstration tests that will be necessary to commercialize enhanced gas recovery technologies as soon as possible.

--Reassess annually the Federal role and level of effort in enhanced oil and gas recovery research and development in the light of increased oil and gas prices and industry's willingness to promote new technology. (See p. 19.)

AGENCY COMMENTS

The Energy Research and Development Administration did not comment on GAO's recommendations. The agency expressed concern that this report had a negative rather than an objective tone and that it failed to present an adequate discussion of the agency's position on the issues in question. Basic differences exist concerning the effectiveness of the agency's program.

The Federal Energy Administration also reviewed a draft of this report and generally agreed with its findings. (See p. 20.)

CHAPTER 1

INTRODUCTION

About 425 billion barrels of crude oil have been discovered in the United States. However, over two-thirds of these already found resources (290 billion barrels) are not economically recoverable at current prices with the conventional technologies now used. Also, vast quantities of natural gas in certain areas of the United States are not commercially producible with current drilling techniques. About 600 trillion cubic feet of such gas may be locked in tight, low permeability formations in deep Rocky Mountain basins. It has also been estimated that as much as 500 to 600 trillion cubic feet of gas may be locked in the Devonian shale formations of Appalachia. The Energy Research and Development Administration (ERDA) is conducting research aimed at developing and demonstrating enhanced recovery techniques to recover this oil and gas.

Today the Nation depends on oil and natural gas to supply over 75 percent of its energy. Although demand for crude oil continues to grow, domestic production has dropped from a peak of 9.6 million barrels a day in 1970 to a current level of 8.2 million barrels a day. Oil imports which provided 23 percent of U.S. oil consumption in 1970 now provide 40 percent. Natural gas production has fallen from a peak of 22.6 trillion cubic feet in 1973 to 20.1 trillion cubic feet in 1975. The result has been forced curtailments in gas usage. Despite these shortfalls in domestic supply, oil and gas will remain important energy sources into the early part of the next century.

ERDA has implemented programs to develop alternative sources of energy, such as solar, oil shale, and geothermal, to help meet our future energy needs. Although these alternative sources hold promise for supplying a portion of the Nation's future energy needs, considerable contributions from these sources are not expected in the near term (1985). Successful development of enhanced recovery technologies offers the potential for increasing our energy supplies and helping reduce our dependence on foreign imports.

ENHANCED RECOVERY--WHAT IS IT?

The term "enhanced recovery" has a distinctly different meaning for the production of oil as contrasted to its meaning in the production of gas. Enhanced recovery of oil refers, for the most part, to increasing the production from producing reservoirs. Enhanced gas recovery generally

refers to the production of gas from areas where commercial production has not previously been possible.

Oil

Oil is not found in large pools or lakes, rather it is found trapped inside the tiny pores of sedimentary rocks, such as limestone or sandstone. Normally when a well is drilled into oil-saturated rock, the natural underground pressures will drive a portion of the oil out of the rock to the well bore where it can be recovered. The process by which oil is produced from these natural pressures is identified as "primary recovery." On the average, only about 15 to 20 percent of a field's oil is produced by natural pressures.

In many oil fields the natural pressures are not sufficient to move the oil. They have diminished over time to a point where the well is no longer productive. By supplementing the natural pressures, additional oil can be recovered. Currently, the most widespread method of extracting oil after natural pressures have diminished is waterflooding; that is, water is pumped into the oil-bearing rock to flood out some of the oil that would not be recovered through natural forces. This process is known as secondary recovery. Although effective, waterflooding can only increase the yield of a well to about 35 percent.

The oil industry has developed much experimental technology for the enhanced recovery of oil beyond the "secondary" level; however, only a few basic methods have been sufficiently advanced by industry to warrant further study for commercial application. The combined production attributed to all the new enhanced recovery technology is less than 250,000 barrels of oil a day and most of this is from steam injection in California. Some of the more promising enhanced recovery techniques which the industry and ERDA have identified include:

--Micellar polymer flooding--The injection of a detergent (micellar fluid) designed to sweep through the reservoir washing oil from the rock grains as it moves. A second substance (polymer) is injected behind the detergent to move it slowly and steadily through the reservoir. (See illustration on p. 4.)

--Hydrocarbon miscible flooding--The injection of solvents, such as kerosene or dry cleaning fluids, to clean the oil from rock. The solvents are driven by gas pressure which pushes the oil to the producing wells. (See illustration on p. 4.)

--Carbon dioxide injection--The use of carbon dioxide (CO_2) under sufficiently high pressure so it can change the characteristics of the oil so that it will flow. (See illustration on p. 4.)

--Thermal recovery--In some cases oil is so thick that it can neither be pumped out of the ground nor dissolved out of the rocks. Thermal recovery involves heating the oil within the reservoir, thus thinning it and allowing it to flow toward the producing well. (See illustration on p. 5.)

After applying these techniques it takes several years to determine their technical and economic feasibility. Commercial application and production will take several years more.

A wide range of estimates has been made of how much oil can be obtained by using these techniques. These estimates range from 15 to 110 billion barrels. ERDA estimates that 40 to 60 billion barrels could be produced using enhanced recovery techniques.

Gas

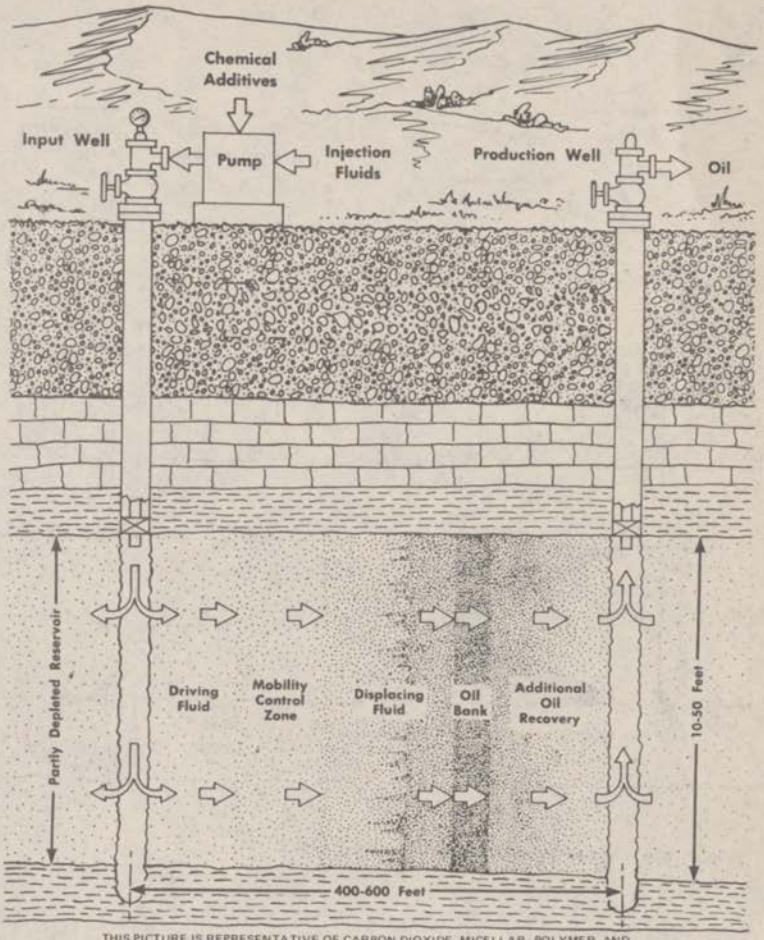
The technology involved in the enhanced recovery of natural gas is quite different than that for the production of oil. The objective of enhanced gas recovery is to expand and extend natural fractures in formations holding gas, causing the gas to flow more rapidly without the need to drill additional wells. Methods of enhanced gas recovery include explosive and hydraulic fracturing and drilling deviated wells.

--Hydraulic fracturing--A fluid containing a "propping" agent, such as sand, is pumped into the well at high pressures. This pressure produces larger and extended fractures, increasing the area from which gas may be recovered. The "propping" agent keeps the fractures open. (See illustration on p. 6.)

--Explosive fracturing--Chemicals, such as nitroglycerin, are placed at the bottom of a well, displaced into fractures, and detonated to stimulate production. (See illustration on p. 7.)

--Deviated wells--Wells are drilled at an angle to increase production by intersecting a maximum number of fractures in gas formations. These "deviated" wells can also be stimulated by hydraulic or explosive fracturing. (See illustration on p. 8.)

ENHANCED RECOVERY THROUGH FLUID DISPLACEMENT METHODS

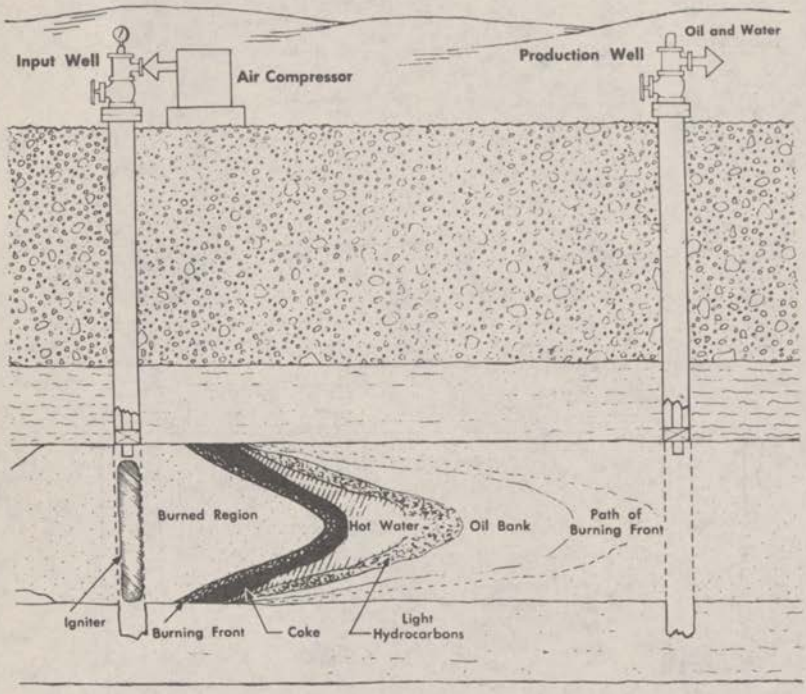


THIS PICTURE IS REPRESENTATIVE OF CARBON DIOXIDE, MICELLAR-POLYMER, AND HYDROCARBON MISCIBLE RECOVERY TECHNIQUES.

SOURCE: MODIFIED VERSION ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION ILLUSTRATION

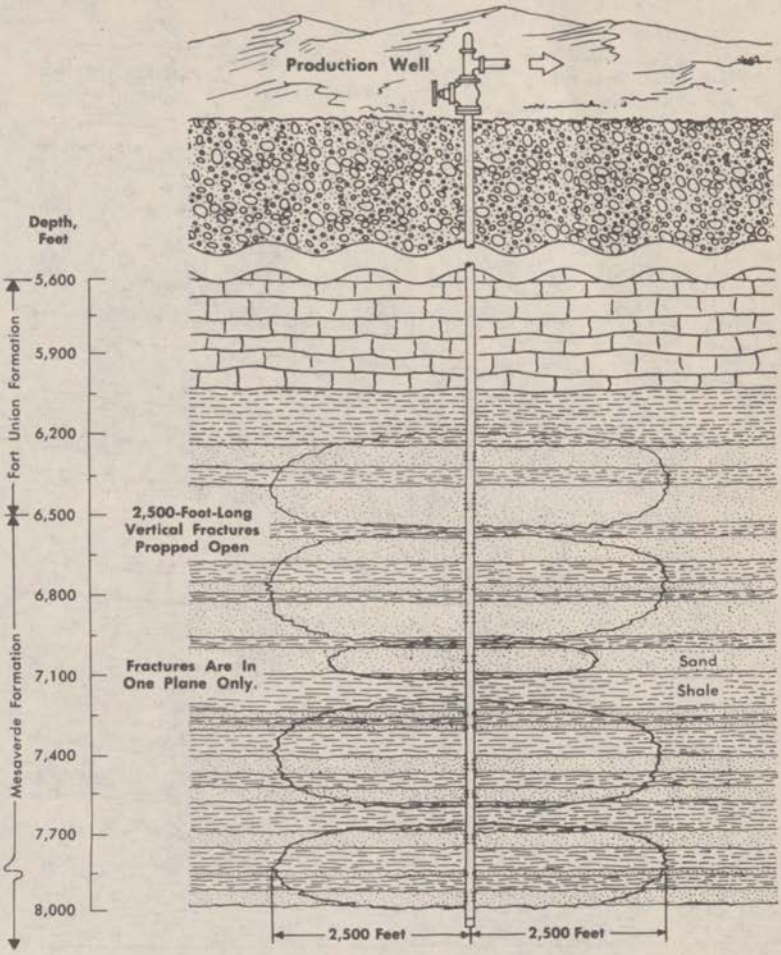
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THERMAL RECOVERY



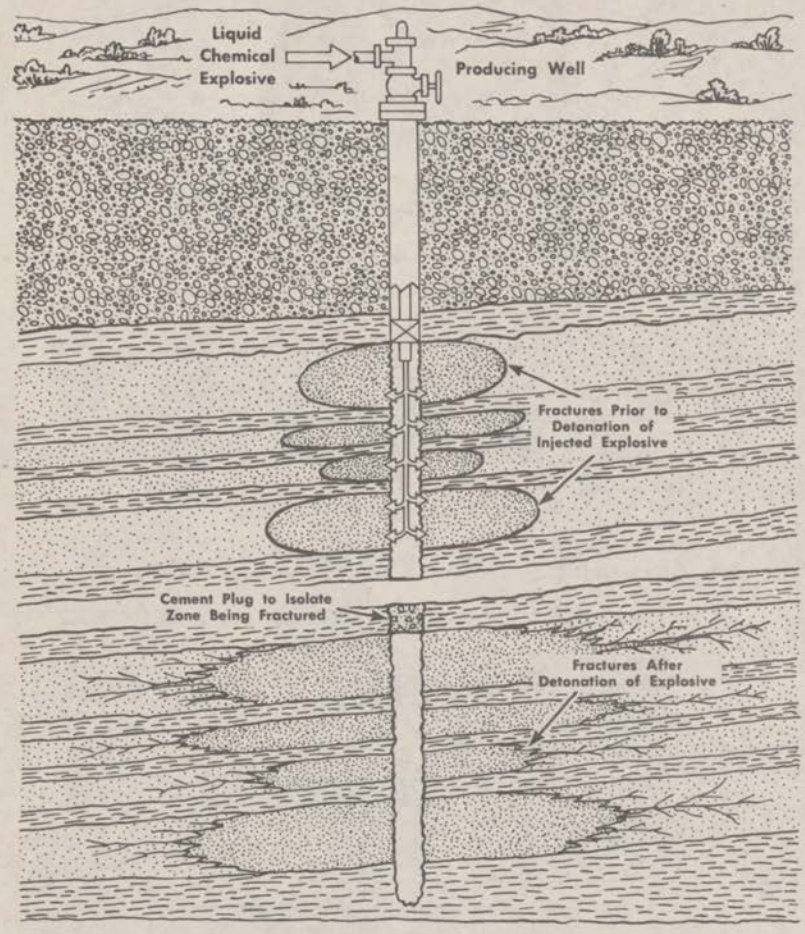
SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PRODUCTION STIMULATION BY MASSIVE HYDRAULIC FRACTURING



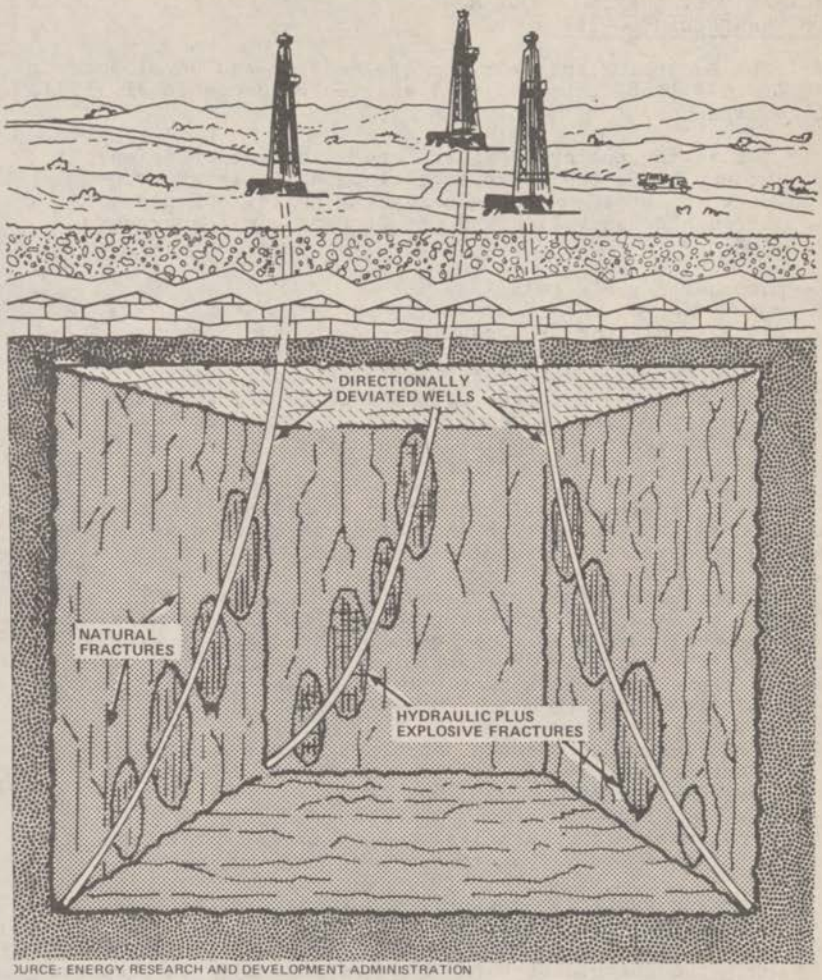
SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CHEMICAL EXPLOSIVE FRACTURING



SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

DIRECTIONALLY DEVIATED WELLS STIMULATED BY HYDRAULIC PLUS EXPLOSIVE FRACTURING



)URCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

ERDA estimates that as much as 300 trillion cubic feet of gas could be produced using these techniques.

FEDERAL COST-SHARING PROGRAM FOR ENHANCED RECOVERY

The Federal Nonnuclear Energy Research and Development Act of 1974 (Public Law 93-577) enacted on December 31, 1974, states that

> "It is the policy of the Congress to develop on an urgent basis the technological capabilities to support the broadest range of energy policy options through conservation and use of domestic resources * * *."

The purpose of the act is

> "* * * to establish and vigorously conduct a comprehensive national program of basic and applied research and development, including but not limited to demonstrations of practical applications, of all potentially beneficial energy sources and utilization technologies, within the Energy Research and Development Administration."

A specific requirement of the act is to demonstrate new and improved methods for extracting petroleum resources, including the enhanced recovery of oil and gas.

In pursuing these objectives, ERDA is implementing an enhanced oil and gas recovery program, building on an earlier Department of the Interior program. The program itself is not intended to produce large quantities of commercial oil and gas. Rather, the program is supposed to stimulate industry to commercialize enhanced recovery processes by

--accelerating, through cooperative cost-sharing contracts, industry's development of enhanced recovery technologies;

--evaluating the technical and economic feasibility of enhanced recovery technologies; and

--making publicly available the results of its research and development efforts.

When the cost-sharing program has proven an enhanced recovery technique in a full-scale demonstration, industry is expected to utilize it and to assume all costs for commercial development.

Under the program, ERDA has a schedule for entering into cooperative arrangements with private firms to make 103 oil and 94 gas enhanced recovery demonstration tests. ERDA's general policy requires the industry participants to contribute at least 50 percent of the project cost. ERDA expects these tests to be conducted over a 7-year period--1974 through 1980, at a cost of about $368 million to the Federal Government. As of mid-September 1976, ERDA had initiated 27 oil and gas demonstration tests. The total estimated cost of these tests is approximately $122 million with ERDA and private industry participants contributing about $46 million and about $76 million, respectively. (See app. IV.)

CHAPTER 2

ERDA'S ENHANCED OIL AND GAS RECOVERY SCHEDULES LACK TIMELINESS

In 1975 ERDA established goals of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes by 1985. The 1985 production goals were recently reduced to 500,000 barrels of oil a day and 3 billion cubic feet of gas a day. However, ERDA's schedules for developing enhanced oil and gas recovery techniques are unlikely to stimulate enough production by industry to reach the agency's 1985 production goals.

ENHANCED OIL RECOVERY SCHEDULE

In 1975 ERDA developed a startup schedule for 103 oil recovery demonstration tests which were thought to be needed to attain the agency's 1985 oil production goals. These tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. This schedule was based primarily on a study made in 1973 by the Gulf Universities Research Consortium for the Atomic Energy Commission. 1/ The consortium reported that a consensus of experts from 22 oil companies predicted that about 91 projects utilizing the 4 most promising enhanced oil recovery methods would be needed in a large percentage of the major producing domestic fields before widespread commercial implementation could be expected. The consortium believed that a large number of projects were needed to confidently predict production from enhanced recovery methods. The consortium concluded that about 1.2 million barrels a day could be produced by 1985 if the 91 field tests were started by 1974 and if reasonable wellhead price increases accompanied development of field test data. The report did not provide estimates of the price level required for the technologies' commercial application.

ERDA implemented a 7-year schedule for awarding contracts extending from 1974-80. ERDA's schedule calls for most tests to be started during the last 3 years of the

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1/ Planning Criteria Relative to a National Research, Development, Testing, and Evaluation Program Directed to the Enhanced Recovery of Crude Oil and Natural Gas, Gulf Universities Research Consortium, November 30, 1973.

7-year period. Of the 103 enhanced oil recovery demonstration tests, 65 are not scheduled to begin until fiscal years 1978 through 1980. ERDA officials told us that a revised schedule will be prepared as part of a new management plan which they are developing. This new plan is discussed on page 18.

Although considerable research and field testing has been done by industry, present knowledge is not adequate to make reasonable estimates of the probable amounts of oil to be recovered from a given reservoir through enhanced recovery techniques. Recovery methods which prove successful in one reservoir may not be productive in others because of variations in reservoir characteristics, such as permeability, porosity, and viscosity. Therefore, to show that these processes can be applied on a widespread commercial basis, demonstrations of their technical and economic feasibility must be performed in many different types of fields.

The period in which the field demonstration tests are completed is vitally important because the test results are to provide the basis for assessing commercial applications. The most promising enhanced oil recovery methods that ERDA expects to develop require several years between field demonstrations, commercial applications, and production. The most promising field demonstration methods require 4 to 5 years to complete.

Since most tests are scheduled to start during the last 3 years of the 7-year period from 1974 through 1980, most of the technical and economic data needed to prove the technologies' commercial feasibility will not be available until the 1982-85 period. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests are available. Therefore, the current ERDA demonstration schedule cannot be expected to result in considerable commercial production before the late 1980s or early 1990s. In addition, the micellar-polymer method requires vast chemical quantities for widespread commercial use. The decision to build the required chemical plants is not expected until a viable market is established. The plants' construction is expected to require an additional 2 to 3 years between decision to build and full capacity production.

The Federal Energy Administration (FEA) has been studying the potential of enhanced recovery and has concluded that it can play an important role in aiding the Nation's energy supply. In 1975 FEA suggested that ERDA accelerate its plan for implementing field demonstration tests by increasing the number of tests during the early years of program implementation, thereby compressing the time frame in which test

results would be available for assessing commercial applications. The cost of ERDA's plan and the accelerated plan FEA suggested generally would be the same. Whereas ERDA's plan requires greater funding in the program's later years, FEA's plan requires higher funding during the program's earlier years.

ERDA concurred, in principle, with FEA's proposal. However, ERDA's Administrator felt that further consideration would have to be given to its organizational capabilities, the time implicit in compliance with all the required reviews and competitive proposal procedures, and to the constraints due to limited availability of the surfactant chemicals used for micellar and improved waterflooding. A comparison of ERDA's schedule and FEA's suggested schedule is shown in figure 1.

NATURAL GAS RECOVERY SCHEDULE

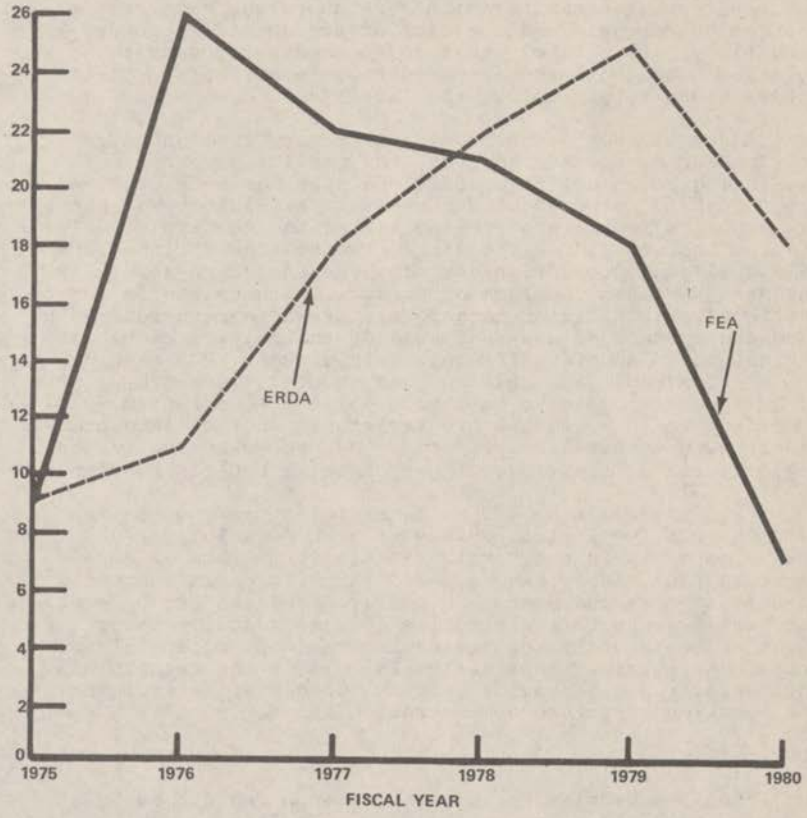
ERDA implemented a schedule for 94 field demonstrations covering the 7-year period 1974-80 to achieve its 1985 production goals. As with oil, these tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. Of the 94 tests, 15 were scheduled to begin in fiscal years 1974 through 1976, with the remaining 79 scheduled for fiscal years 1977-80.

The period between field demonstrations and commercial production of natural gas is less than that of enhanced oil recovery. Field tests can be completed in a relatively short period. However, enhanced natural gas recovery technology is not as far advanced as oil recovery technology. Industry officials stated that more research is needed for natural gas recovery processes. ERDA and industry officials said one of the major reasons for this has been historically low wellhead prices (less than 22 cents a thousand cubic feet until 1974) which provided little incentive for developing advanced technology in this area.

Effective July 27, 1976, the Federal Power Commission (FPC) increased the wellhead ceiling prices for interstate natural gas from 52 cents a thousand cubic feet (Mcf) to $1.42 an Mcf for gas from wells started on or after January 1, 1975, and 93 cents an Mcf for gas from wells started in 1973 and 1974. FPC prescribed that the ceiling price of post-1974 gas could be increased 1 cent an Mcf each quarter starting October 1, 1976. FPC also prescribed that the ceiling price of 1973-74 gas could be increased 1 cent an Mcf annually beginning January 1, 1977. These rate increases

FIGURE 1

ERDA'S ENHANCED OIL RECOVERY FIELD DEMONSTRATION SCHEDULE COMPARED TO FEA'S PROPOSED SCHEDULE (BY FISCAL YEAR)



NOTE: NUMBERS INDICATE PROJECTS PROPOSED DURING EACH FISCAL YEAR; NUMBERS FOR 1976 INCLUDE PROJECTS PLANNED DURING TRANSITION QUARTER BETWEEN FISCAL YEARS 1976 AND 1977

are currently being contested in court and may change. The affect any price increases will have on industry research and development is not yet known, but they are likely to provide additional incentive for industry to develop advanced recovery technologies.

However, because of the slow pace of the Energy Research and Development Administration's enhanced gas recovery demonstration schedule and the lack of fundamental recovery technology, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s.

A few of ERDA's enhanced gas recovery tests have recently been completed; however, the results have been disappointing because little additional gas has been produced. Not enough is known about gas recovery technology and the gas deposits in the areas being tested to adequately evaluate the test results. Therefore, the reasons for the lack of significant production during these tests are generally unknown. Whether the lack of production increases is due to ineffective stimulation techniques, or whether there are inadequate amounts of gas available at the test sites remain unresolved. Industry officials told us that ERDA should implement a rapid and balanced gas recovery research program if gas production is to be increased in the near term. According to them, such a program should include laboratory research, demonstration projects, and the gathering of geological data on the types of gas deposits ERDA is testing.

ERDA has begun a $4.9 million project in cooperation with the U.S. Geological Survey to gather geological data on gas deposits in the Devonian shale formations of Appalachia. ERDA also plans to award $18 million in contracts to universities and State and private research groups over the next 5 years to characterize the gas resource targets in order to identify the areas with the most potential for enhanced recovery. ERDA officials told us the results of this effort should provide a basis for better determining the location of future demonstration tests.

CONCLUSIONS

ERDA's schedules for developing enhanced oil and gas recovery techniques are unlikely to stimulate enough industry production to reach the agency's 1985 oil and gas production goals because the schedules call for most tests to start during the last 3 years of the 7-year period 1974-80.

Since field demonstrations of the most promising oil recovery methods require 4 to 5 years to complete, most of the

technical and economic data needed to prove the technologies' commercial feasibility will not be available until the 1982 to 1985 time frame. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests is available. Therefore, the current ERDA demonstration schedule cannot be expected to result in considerable commercial oil production increases before the late 1980s or early 1990s.

Enhanced gas recovery technology is not as advanced as enhanced oil recovery technology, and the Energy Research and Development Administration's program is proceeding slowly under the current schedule. As a result, although the time between successful demonstration of enhanced gas recovery methods and substantial gas production using these methods is shorter, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s.

CHAPTER 3

NEED FOR AN EFFECTIVE MANAGEMENT PLAN AND IMPROVED PROGRAM IMPLEMENTATION METHODS

ERDA's efforts to develop and demonstrate enhanced recovery tecnnologies nave been hampered by the lack of an effective program management plan. Adequate consideration nas not been given to demonstrating these technologies in the most desirable test fields.

LACK OF AN EFFECTIVE MANAGEMENT PLAN

According to the Office of Management and Budget, ERDA nas not had an effective program management plan for enhanced oil and gas recovery. The Office of Management and Budget's major criticism is that ERDA has not adequately identified those ingredients essential to a successful enhanced recovery program which would result in the most rapid and effective means for increasing domestic petroleum supplies.

Before attempting to implement a field demonstration oil test program, ERDA did not identify those reservoirs with the characteristics which could best demonstrate enhanced oil recovery applications. Without this information, ERDA was unable to specify project requirements in sufficient detail in its requests for proposals to ensure that it would undertake demonstration tests that made the optimum contribution to developing and demonstrating enhanced oil recovery. ERDA officials agreed that their project specifications were too general. According to them, a management plan now under development should enable ERDA to better specify in its requests for proposals the ranges of reservoir and fluid characteristics required for each test.

Furthermore, ERDA officials could not provide any documentation showing why 94 field demonstration tests of enhanced gas recovery were needed or how the scheduling was derived for these tests. They indicated that the schedule stemmed from earlier Department of the Interior planning exercises made before the program was transferred to ERDA in January 1975. ERDA officials were uncertain of how many projects were necessary to develop enhanced gas recovery tecnnologies.

A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide

a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies.

ERDA DEVELOPING A PLAN

ERDA officials told us that, pursuant to an Office of Management and Budget request, they are now developing an ennanced oil recovery program management plan. Areas of stuay which are currently underway include:

--Identifying major oil reservoirs and the assessment of the best enhanced recovery methods to use on each.

--Assessing the production potential of these major oil reservoirs using enhanced recovery techniques.

--Assessing industry's willingness and/or ability to invest in enhanced recovery projects of different types.

--Developing estimates of how much oil would be produced at various price levels, both with and without a Federal research and development program.

--Defining better what the Federal role should be in achieving enhanced oil and gas recovery objectives.

From these studies and subsequent analyses ERDA intends to develop a program management plan which will include:

--The priority of targets for enhanced recovery testing.

--The sequence of tests and cost.

--A system of disseminating technical information.

--A system for measuring the program's effect on production.

--A plan for assessing the environmental consequences of such a program.

ERDA officials told us they started developing a similar management plan for enhanced gas recovery in December 1976.

CONCLUSIONS

If ERDA's oil and gas enhanced recovery program is to contribute considerably to developing these potential energy

sources, a well-defined program management plan is essential. A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies.

ERDA's preparation of an enhanced oil recovery management plan is an important step for an effective enhanced recovery program and, if developed along the lines currently proposed by ERDA, should contribute to an improved program.

Field demonstrations in those reservoirs, to be identified by ERDA in its management plan, having the characteristics which could best demonstrate the technical and economic feasibility of widespread commercial applications, would result in a more effective and timely demonstration program.

In December 1976 ERDA started developing a management plan for enhanced gas recovery. We believe this is an important step in developing an effective enhanced gas recovery program.

RECOMMENDATIONS

We recommend that the Administrator of ERDA:

--Give continued and increased emphasis to developing and putting into operation a management plan for enhanced gas recovery. The plan should focus on developing a balanced research program to include laboratory research, demonstration tests, and the gathering of geological data on the types of deposits the agency plans to test. The plan should also define the number of field demonstration tests that will be necessary to commercialize enhanced gas recovery technologies as soon as possible.

--Reassess annually the Federal role and level of effort in enhanced oil and gas recovery research and development in the light of increased oil and gas prices and industry's willingness to promote new technology.

AGENCY COMMENTS

The Energy Research and Development Administration did not comment on our recommendations. The agency expressed concern that this report had a negative rather than an objective tone and that it failed to present an adequate discussion of the agency's position on the issues in question. Basic differences exist concerning the effectiveness of the agency's program. (See apps. I and II.)

The Federal Energy Administration also reviewed a draft of this report and generally agreed with its findings. (See app. III.)

89-805 O - 77 - 38 (Pt. 8)

CHAPTER 4

PROBLEMS WHICH MAY AFFECT COMMERCIALIZATION OF ENHANCED RECOVERY TECHNIQUES

Government and industry agree that enhanced recovery processes could help increase this Nation's domestic energy supply. However, the time frame in which widespread commercial applications of enhanced recovery techniques might be made and the rate at which these resources will become available is quite uncertain.

Several factors are constraining industry from demonstrating and commercializing enhanced recovery technology. These include:

--The lack of known long-term oil and gas prices against which to calculate economics.

--The large capital investments required.

--The unproven and risky nature of many enhanced recovery techniques.

--Uncertainty as to the future availability of needed recovery materials for the enhanced oil recovery processes.

PRICING

According to industry officials, low oil and gas prices have historically been major constraints to development and commercialization of enhanced recovery. The price levels necessary to produce considerable amounts of oil and gas through enhanced recovery operations are not yet well defined. The costs of these techniques will require prices above those presently paid for domestic production.

Oil

The composite price of domestic oil is about $8 a barrel. Current Organization of Petroleum Exporting Countries (OPEC) prices are about $13 a barrel. Lewin Associates, Incorporated, recently completed a study for FEA which included an analysis of the potential for enhanced recovery in California, Texas, and Louisiana. The study showed that, of the 43.3 billion barrels of oil technically recoverable through enhanced recovery in these States, 30.5 billion barrels

could be economically recoverable at a price of $11.28 a barrel under the most optimistic conditions. Of these same resources, Lewin Associates estimated that only 5.2 billion barrels would be economically recoverable at $5.25 a barrel. It concluded that price strongly affects the quantity of oil to be produced from enhanced recovery techniques.

Some Federal action has been taken to provide additional price incentives for enhanced oil recovery. A recent act (90 Stat. 1125) extending the life of FEA has provided for somewhat greater flexibility in allowing higher regulated prices for oil that is difficult to produce. In this regard, the act requires that early consideration be given to providing additional price incentives for bona fide enhanced recovery techniques.

Our review focused on the management of ERDA's enhanced recovery program. We recognize that increases in the price of oil could stimulate industry research and development and reduce the need for a Federal research and development program in enhanced oil recovery. We did not examine the affect that price increases would have on the need for a Federal enhanced recovery program. However, we plan to consider this question in future work.

Gas

As discussed on pages 13 and 15, FPC increased the regulated wellhead price ceilings for interstate natural gas, effective July 27, 1976, from 52 cents a thousand cubic feet (Mcf) to $1.42 an Mcf for wells started on or after January 1, 1975, and 93 cents an Mcf for wells started in 1973 and 1974. FPC prescribed that the ceiling price of post-1974 gas could increase 1 cent an Mcf each quarter starting October 1, 1976, and that the ceiling price of 1973-74 gas could increase 1 cent annually beginning January 1, 1977. The American Gas Association recently estimated that the cost of producing large quantities of gas using enhanced recovery techniques could range from $1.50 to $2.50 an Mcf.

CAPITAL REQUIREMENTS

Enhanced recovery operations require capital investments far in excess of those required using conventional recovery techniques. The major cost increase for enhanced oil recovery using the carbon dioxide or micellar polymer processes stems from the purchase of injection materials (chemicals and fluids), necessary in removing additional oil from the reservoir. The Lewin Associates study for FEA estimated that $150 billion would be required to produce 30.5 billion barrels from enhanced recovery processes. Some $30 billion

would be required for field development and equipment and an additional $120 billion for injection chemicals and fluids.

Not only are enhanced recovery operations more costly than conventional recovery processes, but much of these costs are incurred long before production starts. Chemicals which are injected in 1976 are not expected to produce oil until about 1980. The pace at which the fluids move through the reservoir cannot be accelerated; therefore, repayment of capital investment will be slower than that of using conventional recovery techniques.

RISK ASSESSMENT

The adequate assessment of risk is considered to be an unavoidable prerequisite to commercializing enhanced recovery processes. Industry officials told us Government participation is necessary in demonstrating and assessing these high risk processes. ERDA's position is that the assessment of risk can only be accomplished by completing many field demonstration tests. Although the period required for assessing these processes through field demonstration tests will directly affect implementing commercial-scale ventures, ERDA, as of mid-September 1976, had only initiated 16 enhanced oil recovery field demonstration tests and 11 natural gas tests. (See app. IV.)

RECOVERY MATERIALS

The enhanced recovery methods ERDA expects to produce the most oil involve the injection of chemicals and fluids into the reservoirs to remove the oil still in place.

Industry officials told us that shortages of these enhanced recovery materials could impede commercializing enhanced recovery technologies. According to a recent Gulf Universities Research Consortium study--based on information obtained from oil and chemical companies--for ERDA, about 3.5 billion pounds of chemicals would be needed annually to maintain production of one-half million barrels of oil a day from the micellar polymer process. Most of the current production of these chemicals is committed to other commercial uses. The study estimated the capital investment required to construct needed additional capacity would be about $1.2 billion. Present chemical production capacity is now considered sufficient to support the field demonstration program. However, commercial application of the processes cannot be made until additional capacity becomes available.

The anticipated increase in chemical demands will require constructing several large chemical plants. However,

ERDA's studies indicate that this expansion will not occur until a viable enhanced recovery market has been established. This can only be accomplished through completing a series of field demonstration tests. ERDA recognizes that a shortage of chemical supplies must be overcome before widespread commercial applications can be made. Also it is recognized that at least 2 to 3 years must be allowed for new chemical plant construction once the decision to build has been made.

Another consideration is the energy intensiveness of the chemicals used in enhanced recovery. Some of the chemicals used in enhanced oil recovery contain large amounts of oil. In addition, energy is required to build and operate the plants which produce the chemicals. The energy intensiveness of chemicals used in enhanced oil recovery will partially offset the energy obtained from these wells. In some cases this offset may be considerable and could be an important consideration in commercializing the processes.

CONCLUSIONS

ERDA considers enhanced recovery to be one of the most effective near-term methods for increasing domestic energy supplies. ERDA's present program, however, does not provide for maximizing the development of these resources in the near term. The assessment of risk has progressed slowly and commercial applications of enhanced recovery techniques are not expected until such an assessment is completed. Delays in commercial applications are further compounded by possible shortages of injection materials, plus high capital investment.

Price levels necessary to provide enhanced recovery resources have not been firmly identified; however, pricing is a primary determinant in assessing commercial applications. Adequate price levels against which economics could be calculated are essential for establishing industry confidence.

These constraints could slow commercialization of enhanced oil and gas recovery and could interact to make ERDA's revised goals of increased oil and gas production even more difficult to achieve.

CHAPTER 5

SCOPE OF REVIEW

We directed our review at the management of ERDA's enhanced oil and gas recovery program. We interviewed officials at the following locations.

--ERDA Headquarters, Washington, D.C.

--Bartlesville Energy Research Center, Bartlesville, Oklahoma.

--Federal Energy Administration Headquarters, Washington, D.C.

--Gulf Universities Research Consortium, Houston, Texas.

--University of Tulsa, Tulsa, Oklahoma.

--Cities Service Oil Company, Wichita, Kansas.

--Phillips Petroleum Company, Bartlesville, Oklahoma.

--Kewanee Oil Company, Tulsa, Oklahoma.

--Amoco Production Company, Tulsa, Oklahoma.

--Shell Oil Company, Houston, Texas.

--Penn Grade Crude Oil Association, Bradford, Pennsylvania.

--Guyan Oil Company, Parkersburg, West Virginia.

--CER Geonuclear Corporation, Las Vegas, Nevada.

--Columbia Gas System Service Corporation, Columbus, Ohio.

--El Paso Natural Gas Company, El Paso, Texas.

--Physics International Company, San Leandro, California.

--Kentucky-West Virginia Gas Company, Prestonburg, Kentucky.

--Mobil Oil Corporation, Dallas, Texas.

--Continental Oil Company, Houston, Texas.

--Gulf Oil Corporation, Houston, Texas.

--Oil and Gas Journal, Tulsa, Oklahoma.

AGENCY COMMENTS AND

GAO EVALUATION

In a letter dated September 14, 1976, ERDA commented on a draft of this report. Presented below is the text of the agency's comments, along with our evaluation.

ERDA COMMENT

"Dear Mr. Canfield:

"Thank you for the opportunity to comment on the draft report entitled 'Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly.'

"We have reviewed the draft with members of your staff and we understand that a number of changes and clarifications which we suggested will be made. There are, however, several additional changes which we would like to see made in order that the report may become a more objective, meaningful document for the Congress.

"In addition to being somewhat dated, in general, we find that the report has a negative rather than an objective tone and fails to present an adequate discussion of ERDA's positions on the issues in question. Even the title seems to reflect this tone, and may bias the reader from the outset. We would suggest a more objective title such as 'An Evaluation of ERDA's Enhanced Oil and Gas Recovery Program.' Indeed, the report discusses only ERDA's program, but does not include other parts of the 'Federal Effort,' such as the regulatory program.

"Frequent comments are made about the need for enhanced oil and gas recovery management plans, but the report does not recognize that both programs (oil and gas) started with program plans. These have since evolved along with the state of knowledge and industry attitudes.

"Industry opinions are cited in numerous places. It is important to recognize that the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil have changed considerably over

the past few years. It would be in order for GAO to obtain a current industry opinion."

GAO EVALUATION

Our report is current and not dated. We initiated the review in August 1975, and our draft report submitted to ERDA reflects information obtained from the Federal Government and industry sources through July 1976. Although the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil may have changed considerably over the past few years, as stated by ERDA, most of our discussions with industry on these matters have all taken place within the past year.

We have revised the report to show that the number of ERDA-enhanced oil and gas projects has increased from 15 in our draft report to 27 as of August 1976 with the Federal commitment to the projects increasing from about $23 million to about $47 million.

As part of the Energy Reorganization Act of 1974, the Bureau of Mines (BOM) enhanced recovery program was transferred to ERDA in January 1975. Shortly after the reorganization, ERDA published "A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future" (June 1975) which set a goal of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes. However, ERDA did not develop a plan to meet these highly optimistic goals or to increase the recovery of oil and gas at the earliest possible date using enhanced techniques. Rather, ERDA awarded contracts to interested and qualified firms expressing a desire to participate in the BOM program. In fact, most of ERDA's contracts awarded during 1975 were initiated by BOM. ERDA recognized that the achievement of its June 1975 goals was not possible and reduced these goals to 500,000 barrels a day and 3 billion cubic feet a day by 1985. In addition, ERDA is currently reexamining these revised production goals.

This report attempts to put in perspective the fact that ERDA has had to drastically reduce the production goals it initially set for enhanced oil and gas recovery. Although it would be difficult to predict to what extent ERDA's initial goals could have been achieved, one of the major reasons contributing to reducing the goals was the lack of

a well-defined program relating projects and fields to the established goals.

ERDA COMMENT

> "The reduction in ERDA's goals for increased national production of oil and gas from enhanced recovery methods reflects a change during the past two years in the attitudes of the petroleum industry, particularly toward enhanced oil recovery. In 1974, the industry felt it had enhanced recovery technology on the shelf, ready to be used if only the price of oil could make these expensive processes profitable. Early ERDA goals reflected this optimistic industry belief. In 1974, large increases in oil prices provided the impetus to invest in field applications of advanced recovery technologies. Only then was it realized that not enough was known about the physics, chemistry and engineering of petroleum reservoirs and their interaction with the injection materials used for enhanced recovery. In mid-1974, the best physical chemists in the larger oil companies were assigned to the enhanced recovery problem and the information gained since then has served to make the industry more cautious in its assessment of these processes and their potential."

GAO EVALUATION

This information was available to ERDA when it established its initial production goals in June 1975. As early as 1973, a study the Gulf Universities Research Consortium made for the Atomic Energy Commission/ERDA pointed out that

> "the state of knowledge regarding enhanced methods and their application to varying reservoir characteristics, size, depth, lithology, etc. denies any reasonable estimate of the probable recovery in a specific reservoir. Only large-scale field tests supplemented with highly directed supplemental R&D can overcome this difficulty."

This information, along with other information developed by industry since 1974, which ERDA states has made industry more cautious in its assessment of these processes and their potential should have been reflected in the 1975 goals.

ERDA COMMENT

"It is incorrect to state that ERDA does not have a program management plan for enhanced oil and gas recovery. The enhanced recovery program has been guided by a 1974 (Interior) proposal for a five year plan since its inception and the current and planned projects are a result of that plan. Naturally, as industry attitudes towards enhanced recovery have changed, the Government's role has changed and its program plan has evolved. Our current efforts are aimed at improving the existing plan and grounding it on a firm analytical basis, but the program to date has certainly not been aimless. It has been based on experience and the best information available. As such, it has been the product of an evolutionary process. An improved management plan is expected to be implemented in October 1976. An updated estimate of the number, type and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of this improved management plan."

GAO EVALUATION

In our draft report we did not state that ERDA does not have a program management plan. Rather, we stated that:

"ERDA's efforts to develop and demonstrate enhanced recovery technologies have been hampered by the lack of an effective program management plan."

When the program was transferred from BOM, ERDA did not develop a revised program to meet ERDA's goals or to optimize enhanced recovery.

The Office of Management and Budget has also criticized ERDA for not developing an effective program management plan for enhanced oil and gas recovery. The Office of Management and Budget informed us that ERDA has not adequately identified those ingredients essential to a successful enhanced recovery program which could result in the most rapid and effective methods for increasing domestic petroleum supplies. As a result, the Office of Management and Budget has required ERDA to improve its existing management plan by performing a detailed analysis of the Federal role in enhanced recovery and the proper scope and content of a research and development program. More specifically, ERDA has been requested to (1) provide estimates of the value

APPENDIX I

of a Federal research and development program in enhanced oil recovery as compared to, and in combination with, other Federal initiatives to encourage commercialization of tertiary recovery technologies and (2) analytically develop a research and development plan for the most effective allocation of ERDA's enhanced oil recovery budget. Pursuant to the Office of Management and Budget's request, ERDA started the same type of study for its enhanced gas recovery program in December 1976.

[See GAO note, p. 35.]

[See GAO note, p. 35.]

ERDA COMMENT

"The GAO report cites, in several places, an ERDA schedule for awarding contracts to conduct demonstration tests and criticizes it for planning to start most of the tests during the latter years of a seven year program. It should be noted that what the report refers to is not an ERDA schedule, but three different projections of how different funding distribution, over a five year period, might be reflected in actual field test starts. These projections were reflected in a July 17, 1975, letter from Dr. Seamans to Frank Zarb in response to an accelerated funding schedule suggested by FEA. The ERDA letter clearly indicated that while we concurred with FEA's suggestion in principle, there were a number of factors which ERDA needed to consider before reconciling the exact level of acceleration."

GAO EVALUATION

We agree that the 103 field demonstration tests were outlined in a letter to the Administrator of the Federal Energy Administration projecting how different funding distribution over a 5-year period might be reflected in actual field starts. However, this projection/schedule was at that time, and still is, ERDA's basis for carrying out its enhanced oil recovery demonstration tests. ERDA could not provide us with any other document outlining its planned strategy for carrying out its demonstration tests. ERDA officials told us that an updated estimate of the number, type, and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of its improved management plan.

ERDA COMMENT

"ERDA's position is not the result of a lack of understanding of the need for urgency; rather, it is affected by the following factors:

"A. ERDA has constraints on the amount of money it can spend on enhanced recovery projects and on the manpower resources it can call up on to plan, prepare, execute and manage procurements and monitor projects. For the available manpower resources, we believe that the program is moving as fast as possible and, as discussed above, is undergoing reexamination. Development of the improved management plan may require a different mix of people and dollars than the present effort."

GAO EVALUATION

We agree that funding and manpower resources place constraints on what can be accomplished under a particular program. Office of Management and Budget officials indicated to us and to ERDA in budget negotiations that they were not satisfied with ERDA's current approach for managing the enhanced oil and gas recovery programs. As a result, the Office of Management and Budget directed ERDA to develop an improved management plan.

The Office of Management and Budget suggested ERDA's revised management plan include (1) estimates of the value of a Federal research and development program in enhanced oil recovery and (2) an analytically developed research and development plan demonstrating the most effective allocation of ERDA's enhanced oil recovery budget. If ERDA had, at the start of the program, developed a plan with these elements, it would have had a better basis for justifying requests for additional funds to the Office of Management and Budget.

ERDA COMMENT

"B. It must be recognized that the accelerated strategy suggested by the GAO is a much riskier one than ERDA's present plan. The accelerated schedule would force ERDA to plunge into an intensive and expensive effort with a minimum amount of information, understanding and planning. While the early field tests that ERDA is conducting may not achieve commercial production for eight to ten years, they provide very valuable performance data after two or three years, enabling us to plan

for and choose the later projects much more effectively. To accelerate the schedule of projects, we may need to accept proposals in advance of information developed by projects, accept proposals that are inferior to those we have already funded, or force proposals from companies that have not planned and budgeted for such projects. As information from the earlier tests is made available, more companies should be encouraged to plan for and seek joint projects with ERDA."

GAO EVALUATION

Risky projects of this nature are directly in line with ERDA's role. ERDA's role, as set forth in "A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future 1976," is as follows:

"Since the development and application of enhanced oil and gas recovery technologies involve high risk and long lead times, the government is providing incentives for industry to accelerate development; the primary responsibility for commercialization, however, lies with industry.

"The present program provides industry incentives through cost-sharing, and thus risk-sharing R&D contracts with industry."

Enhanced recovery appears to have great potential in increasing our domestic energy supplies (40 to 60 billion barrels, according to the latest ERDA estimate) and it may be beneficial to the Nation for the Federal Government to assume some additional risks in this area. Hopefully, the information ERDA is developing for its new management plan will assist ERDA in identifying those reservoirs it needs for its tests and if program acceleration is warranted, allow the agency to do so without accepting inferior proposals.

ERDA COMMENT

"It is true that enhanced gas recovery technology is not as far advanced as that of recovering oil. This is due to the fact that up until 1974 the wellhead price for natural gas was under twenty cents per thousand cubic feet (MCF). No incentive was present to develop advanced--and necessarily expensive--technologies to recover such a low-value commodity.

> Even today, natural gas price regulation dampens industry interest and creates great economic uncertainties with respect to enhanced gas recovery."

GAO EVALUATION

The purpose of this section is to report on the status of ERDA's enhanced gas recovery efforts and to show that the program is not moving along as fast as it should.

We recognize that keeping the wellhead price of natural gas down may hinder research and development and may create economic uncertainties with respect to enhanced gas recovery and have revised the report to show ERDA's concern for the effects of gas pricing on research and development.

ERDA COMMENT

> "The enhanced gas recovery tests conducted to date should not be called failures. Much very valuable information was learned about displacing chemical explosives in fractures and detonation of the explosives. The success of these tests cannot be measured in terms of gas production, especially considering the quality of the wells made available for the tests."

GAO EVALUATION

In our report we do not state that the enhanced gas recovery tests were failures. Instead, we point out that the results have been disappointing because little additional gas had been produced. We also point out that the reasons for the lack of considerable production during these tests are generally unknown. While we agree that some valuable information may have been learned about displacing chemical explosives in fractures and about detonating them, it is nevertheless difficult to measure the worth of the information ERDA may have obtained from these tests.

[See GAO note.]

GAO note: Three comments in ERDA's letter were deleted because of changes to the final report.

 APPENDIX II

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

SEP 14 1976

Mr. Monte Canfield, Jr., Director
Energy and Minerals Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Canfield:

Thank you for the opportunity to comment on the draft report entitled "Enhanced Oil and Gas Recovery -- Federal Effort Moving Slowly."

We have reviewed the draft with members of your staff and we understand that a number of changes and clarifications which we suggested will be made. There are, however, several additional changes which we would like to see made in order that the report may become a more objective, meaningful document for the Congress.

In addition to being somewhat dated, in general, we find that the report has a negative rather than an objective tone and fails to present an adequate discussion of ERDA's positions on the issues in question. Even the title seems to reflect this tone, and may bias the reader from the outset. We would suggest a more objective title such as "An Evaluation of ERDA's Enhanced Oil and Gas Recovery Program." Indeed, the report discusses only ERDA's program, but does not include other parts of the "Federal Effort," such as the regulatory program.

Frequent comments are made about the need for enhanced oil and gas recovery management plans, but the report does not recognize that both programs (oil and gas) started with program plans. These have since evolved along with the state of knowledge and industry attitudes.

Industry opinions are cited in numerous places. It is important to recognize that the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil have changed considerably over the past few years. It would be in order for GAO to obtain a current industry opinion.

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Attached are comments on specific remaining issues discussed in the report which we would like to see modified so as to reflect our views. They do not represent the total editorial change necessary to implement the suggested modifications throughout the document.

Sincerely,

M. C. Greer
Controller

Attachment:
As stated

APPENDIX II

ATTACHMENT

Reduction of 1985 Production Goals

The reduction in ERDA's goals for increased national production of oil and gas from enhanced recovery methods reflects a change during the past two years in the attitudes of the petroleum industry, particularly toward enhanced oil recovery. In 1974, the industry felt it had enhanced recovery technology on the shelf, ready to be used if only the price of oil could make these expensive processes profitable. Early ERDA goals reflected this optimistic industry belief. In 1974, large increases in oil prices provided the impetus to invest in field applications of advanced recovery technologies. Only then was it realized that not enough was known about the physics, chemistry and engineering of petroleum reservoirs and their interaction with the injection materials used for enhanced recovery. In mid-1974, the best physical chemists in the larger oil companies were assigned to the enhanced recovery problem and the information gained since then has served to make the industry more cautious in its assessment of these processes and their potential.

Lack of Management Plan

It is incorrect to state that ERDA does not have a program management plan for enhanced oil and gas recovery. The enhanced recovery program has been guided by a 1974 (Interior) proposal for a five year plan since its inception and the current and planned projects are a result of that plan. Naturally, as industry attitudes towards enhanced recovery have changed, the Government's role has changed and its program plan has evolved. Our current efforts are aimed at improving the existing plan and grounding it on a firm analytical basis, but the program to date has certainly not been aimless. It has been based on experience and the best information available. As such, it has been the product of an evolutionary process. An improved management plan is expected to be implemented in October 1976. An updated estimate of the number, type and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of this improved management plan.

[See GAO note, p. 40.]

[See GAO note, p. 40.]

Demonstration Schedule Lacks Urgency

The GAO report cites, in several places, an ERDA schedule for awarding contracts to conduct demonstration tests and criticizes it for planning to start most of the tests during the latter years of a seven year program. It should be noted that what the report refers to is not an ERDA schedule, but three different projections of how different funding distribution, over a five year period, might be reflected in actual field test starts. These projections were reflected in a July 17, 1975, letter from Dr. Seamans to Frank Zarb in response to an accelerated funding schedule suggested by FEA. The ERDA letter clearly indicated that while we concurred with FEA's suggestion in principle, there were a number of factors which ERDA needed to consider before reconciling the exact level of acceleration.

ERDA's position is not the result of a lack of understanding of the need for urgency; rather, it is affected by the following factors:

A. ERDA has constraints on the amount of money it can spend on enhanced recovery projects and on the manpower resources it can call up on to plan, prepare, execute and manage procurements and monitor projects. For the available manpower resources, we believe that the program is moving as fast as possible and, as discussed above, is undergoing reexamination. Development of the improved management plan may require a different mix of people and dollars than the present effort.

B. It must be recognized that the accelerated strategy suggested by the GAO is a much riskier one than ERDA's present plan. The accelerated schedule would force ERDA to plunge into an intensive

and expensive effort with a minimum amount of information, understanding and planning. While the early field tests that ERDA is conducting may not achieve commercial production for eight to ten years, they provide very valuable performance data after two or three years, enabling us to plan for and choose the later projects much more effectively. To accelerate the schedule of projects, we may need to accept proposals in advance of information developed by projects, accept proposals that are inferior to those we have already funded, or force proposals from companies that have not planned and budgeted for such projects. As information from the earlier tests is made available, more companies should be encouraged to plan for and seek joint projects with ERDA.

Slow Progress in Gas Recovery Technology

A. It is true that enhanced gas recovery technology is not as far advanced as that of recovering oil. This is due to the fact that up until 1974 the wellhead price for natural gas was under twenty cents per thousand cubic feet (MCF). No incentive was present to develop advanced--and necessarily expensive--technologies to recover such a low-value commodity. Even today, natural gas price regulation dampens industry interest and creates great economic uncertainties with respect to enhanced gas recovery.

B. The enhanced gas recovery tests conducted to date should not be called failures. Much very valuable information was learned about displacing chemical explosives in fractures and detonation of the explosives. The success of these tests cannot be measured in terms of gas production, especially considering the quality of the wells made available for the tests.

[See GAO note.]

GAO note: Three comments in ERDA's letter were deleted because of changes to the final report.

FEDERAL ENERGY ADMINISTRATION
WASHINGTON, D.C. 20461

SEP 15 1976 OFFICE OF THE ASSISTANT ADMINISTRATOR

Mr. Monte Canfield
Director, Energy and Mineral Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Canfield:

This responds to your letter of August 9, 1976, regarding your report, "Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly." The report has been reviewed, as requested, and comments are attached. Briefly, it is agreed that Enhanced Oil Recovery (EOR) has not contributed very much toward increasing hydrocarbon production. Some of the problems with EOR are discussed in the attached comments. Generally, the EOR technology is old and applications have not been very successful.

If we can be of further assistance, please do not hesitate to contact us.

Sincerely,

William G. Rosenberg
Assistant Administrator
Energy Resource Development

Enclosure

The GAO report, "Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly," is a critique of the Energy Research and Development Administration (ERDA) effort and contains recommendations for improving ERDA performance.

The enhanced oil recovery contribution to oil production is hardly increasing in spite of Federal efforts as the Government Accounting Office (GAO) points out. The following discussion is offered in consideration of the ERDA program.

Enhanced Oil Recovery (EOR)

Industry has been concerned with enhanced oil recovery for most of the present century. The EOR techniques which first proved commercial were waterflooding and, to a lesser degree, gas driving. Vacuum was widely applied to producing wells, however the beneficial effects were due mostly to resulting gas drive.

Combustion in oil reservoirs was attempted early in the century, but the technology was too crude for success. On the other hand, air injection, a form of gas driving, was fairly widely used. Combustion has not been an important EOR technique and is generally thought to have a relatively restricted usage.

Subsequent to World War II, industry undertood an intense EOR research program. Most major oil companies had research programs in thermal, surface active agents, miscible, carbon dioxide, wettability-reversal, and some forms of mobility control for improving oil recovery efficiency. In the 1950's field tests were undertaken in thermal methods (Mobile, Sinclair), miscible (Stanolind, Atlantic, Humble), wettability-reversal (Stanolind) carbon dioxide (ORCO and others), etc. None of these techniques have found wide application. The most successful by far has been steam injection in the heavy oil reservoirs in California. However, outside that State, the technique is rarely used. Most of the other test results were economic failures. The research effort in all techniques is continuing and getting quite sophisticated in all areas. The sophistication normally indicates significant increases in cost for the processes.

The introduction of high molecular weight polymers in the 1960's, particularly polyacrylamide for mobility control, spawned a new wave of tests. Polymers were tried to increase waterflood efficiency with spotty success. Polymer technology was then linked to surfactant technology in hopes of obtaining a synergistic benefit. This technology is still developing, but the expenses are very high without much indication of commensurate reward.

Test of combustion waves, selective plugging, frontal displacement by steam, alcohols, combinations of combustion and water injection, and carbonated waterflooding have been economic failures except in unique cases.

The purpose of this discussion is to indicate that EOR is an oil topic in the oil industry. The patent and technical literature on the subject is vast. The successes of new EOR technology, steam in California and carbon dioxide in Scurry County, Texas, and high pressure miscible gas in Crane County, Texas, were projects started years ago when oil was fourfold less expensive. The processes have had a very minor impact on increased production since the embargo. A significant and essential consideration in the Texas EOR projects was the increased production allowed by the Texas Railroad Commission. Since production is hardly restricted by regulation at present, this incentive is no longer applicable.

The combined production attributed to all the new EOR technology is less than 250,000 barrels of oil per day and most of this is from steam injection in California.

The entry of ERDA into the EOR field was stimulating and helpful. Unfortunately, the projects they had to choose from were pretty well shopworn. The state of the art may have contributed to the contracting problems discussed by GAO. The selection of prospects for support would require a thorough geologic review to assure the lithology, mineralogy, reservoir continuity, structure, etc., was compatible with the proposed process. The particular process would have to be evaluated against prior results and technically evaluated to assure that a reasonable contribution to the oil recovery art would be obtained. Additionally, the bureaucratic contracting process would impose additional delays.

Tight Gas Reservoir Stimulation

The same general comments made concerning EOR also apply to stimulation of tight gas reservoirs. Industry has tried many different stimulation techniques including hydraulic fracturing, a variety of chemical explosives, and nuclear explosives. Those which have responded sufficiently to be economically attractive have been developed, but the large volume of gas in the tighter reservoirs to which GAO points are not good candidates.

It is probable that technology to develop these tight gas reservoirs is still in the research stage and the success of such research cannot be determined. In the meantime, it would appear the only course left to ERDA is to push for projects using the old techniques.

General

A significant problem with government sponsorship of hydrocarbon recovery techniques concerns propriety considerations. Any EOR technique which is successful is a very valuable property and would almost certainly be protected by patents or, less likely, maintained as a trade secret.

The nominal contribution by government, compared to the potential of a successful EOR technique, may not be worthwhile. This would tend to reduce the ERDA opportunities to second-class prospects.

The development of a management plan as requested on page 24 of the report is a difficult task. The determination of the most efficient type of EOR technique to use could be presumptuous at the present level of technology. As a matter of fact, reservoir damage could be incurred which could cost the Nation future reserves recoverable by some new appropriate technique.

The lack of equipment, materials, and supplies as a problem in starting EOR projects is probably an excuse rather than a reason. Short-term shortages may be expected for some items. However, the chemical and equipment industry inherently respond faster than the oil industry. Shortages, other than short-term, are unlikely.

APPENDIX IV

STATUS OF MAJOR ERDA FIELD DEMONSTRATION PROJECTS AS OF SEPTEMBER 20, 1976

OIL

1. Contractor: Cities Service Oil Company
   Contract Date: June 26, 1974
   Anticipated Completion: October 1978
   Total Project Cost: $7,098,394
   Government Award: $3,002,117
   Type Project: Micellar-Polymer Flood

   PROJECT STATUS

   Prime attention has been given to treating selected wells with an acid solvent and conducting other tests. The preliminary test results were reported to have been encouraging.

2. Contractor: Phillips Petroleum Company
   Contract Date: May 12, 1975
   Anticipated Completion: August 1979
   Total Project Cost: $9,764,514
   Government Award: $3,402,042
   Type Project: Micellar-Polymer Flood

   PROJECT STATUS

   Construction and installation of facilities and equipment is nearing completion. Reservoir evaluation testing is underway and simulations of production and injection rates are being performed.

3. Contractor: Penn Grade Crude Oil Association
   Contract Date: June 30, 1975
   Anticipated Completion: June 30, 1980
   Total Project Cost: $4,444,000
   Government Award: $2,222,000
   Type Project: Micellar-Polymer Flood

   PROJECT STATUS

   Preliminary testing was underway to determine the feasibility of micellar-polymer flooding of low permeability reservoirs. The injection of a biopolymer was begun in October 1975 and continued through February 1976. Test data obtained from these injections were being evaluated for transient fluid flow characteristics.

4. Contractor: Gary Operating Company
Contract Date: June 30, 1976
Anticipated Completion: June 30, 1981
Total Project Cost: $5,039,000
Government Award: $2,519,500
Type Project: Micellar-Polymer Flood

PROJECT STATUS

New Project

5. Contractor: City of Long Beach
Contract Date: July 6, 1976
Anticipated Completion: December 31, 1980
Total Project Cost: $7,000,000
Government Award: $3,500,000
Type Project: Micellar-Polymer Flood

PROJECT STATUS

New Project

6. Contractor: Guyan Oil Company, Inc.
Contract Date: September 1, 1975
Anticipated Completion: August 31, 1978
Total Project Cost: $3,246,260
Government Award: $1,200,000
Type Project: Carbon Dioxide Injection

PROJECT STATUS

Final project design and installation of facilities is expected to take about 12 months. Injection and evaluation phases are expected to require 24 months for a total project life of 3 years.

7. Contractor: Columbia Gas Transmission Corp.
Contract Date: June 3, 1976
Anticipated Completion: June 1979
Total Project Cost: $1,416,316
Government Award: $ 472,300
Type Project: Carbon Dioxide Injection

PROJECT STATUS

This is a new project. Reservoir pressure was raised up to 1,000--1,200 psi before the contract started. Carbon dioxide injection was started in July. Carbon dioxide injection rates are now being balanced to equalize injection volumes.

8. Contractor: Pennzoil Company
Contract Date: June 30, 1976
Anticipated Completion: July 1981
Total Project Cost: $2,627,500
Government Award: $1,021,450
Type Project: Carbon Dioxide Injection

PROJECT STATUS

New Project

9. Contractor: Kewanne Oil Company
Contract Date: June 26, 1975
Anticipated Completion: May 1979
Total Project Cost: $3,884,890
Government Award: $1,150,752
Type Project: Polymer Flood

PROJECT STATUS

Field activity has been directed toward installing equipment and facilities. Preparations were being made for a mini-injectivity chemical test.

10. Contractor: Shell Oil Company
Contract Date: June 26, 1975
Anticipated Completion: June 30, 1979
Total Project Cost: $7,374,872
Government Award: $2,168,206
Type Project: Polymer Flood

PROJECT STATUS

The water injection facilities and the polymer injection facilities were 92 percent completed. The production facilities were in service and tests were being run to establish the accuracy of the test equipment.

11. Contractor: Husky Oil Company
Contract Date: January 24, 1975
Anticipated Completion: January 23, 1980
Total Project Cost: $6,791,800
Government Award: $2,000,000
Type Project: Thermal Recovery

PROJECT STATUS

Development drilling for the project was completed in January 1976. Reservoir and

geological evaluations have been made and steam stimulation of selected test wells has been accomplished. An increase in production of about 30 percent was attributed to the steam stimulation. Production averaged 43 barrels a day from 9 test wells.

12. Contractor: Hanover Petroleum Company
Contract Date: January 24, 1975
Anticipated Completion: January 23, 1979
Total Project Cost: $3,048,059
Government Award: $ 951,725
Type Project: Thermal Recovery

PROJECT STATUS

Several attempts were made to ignite one test well during the period of October 1, 1975, through January 1, 1976. On February 2, 1976, the company decided to abandon the well due to mechanical problems and high injection pressures and selected another well for testing.

13. Contractor: Carmel Energy, Inc.
Contract Date: April 1, 1976
Anticipated Completion: September 30, 1977
Total Project Cost: $825,534
Government Award: $675,547
Type Project: Thermal Recovery

PROJECT STATUS

Construction has commenced on the new Vapor Thermal unit for recovery of heavy oil. Drilling has started on the process wells.

14. Contractor: Getty Oil Company
Contract Date: June 25, 1976
Anticipated Completion: July 1980
Total Project Cost: $8,700,000
Government Award: $2,000,000
Type Project: Thermal Recovery

PROJECT STATUS

New Project

15. Contractor: Cities Service Oil Company
Contract Date: June 1, 1976
Anticipated Completion: June 30, 1982
Total Project Cost: $8,229,000

Government Award: $3,102,000
Type Project: Thermal Recovery

PROJECT STATUS

New Project

16. Contractor: Chanslor Western Company
Contract Date: June 16, 1976
Anticipated Completion: June 1983
Total Project Cost: $8,247,000
Government Award: $1,700,000
Type Project: Thermal Recovery

PROJECT STATUS

New Project

NATURAL GAS

17. Contractor: CER Geonuclear Corporation
Contract Date: June 19, 1974
Anticipated Completion: March 1977
Total Project Cost: $3,475,000
Government Award: $1,975,000
Type Project: Massive Hydraulic Fracture

PROJECT STATUS

Two massive hydraulic fractures have been completed. Results from these fractures were well below expectations. Plans for third and fourth fracturing phases are being studied.

18. Contractor: Columbia Gas System Service Corp.
Contract Date: June 18, 1975
Anticipated Completion: December 1977
Total Project Cost: $4,395,000
Government Award: $2,154,155
Type Project: Massive Hydraulic Fracture

PROJECT STATUS

In January 1976, ERDA reported that surface ownership complications had delayed access to the planned well site location which required the first of three wells to be relocated. As a result, field activities are 3 months behind schedule. In March 1976, studies to determine the design of stimulation treatments were reportedly in progress.

19. Contractor: Columbia Gas Systems Inc.
Contract Date: July 29, 1976
Anticipated Completion: February 1979
Total Project Cost: $4,803,715
Government Award: $2,500,000
Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

20. Contractor: Gas Producing Enterprises, Inc.
Contract Date: September 9, 1976
Anticipated Completion: April 1978
Total Project Cost: $6,986,000
Government Award: $2,155,000
Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

21. Contractor: Mobil Oil Corp.
Contract Date: August 27, 1976
Anticipated Completion: February 1978
Total Project Cost: $6,566,675
Government Award: $2,600,000
Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

22. Contractor: Pacific Transmission Supply Co.
Contract Date: September 13, 1976
Anticipated Completion: January 1979
Total Project Cost: $2,395,512
Government Award: $1,098,755
Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

23. Contractor: Physics International Company
Contract Date: May 15, 1975
Anticipated Completion: October 14, 1976
Total Project Cost: $381,356
Government Award: $381,356
Type Project: Novel Fracturing Technique

PROJECT STATUS

The objective of this project is to develop and evaluate a method of well stimulation that is based on generating a multiple vertical fracture pattern in a gas or oil-bearing reservoir. Five wells were stimulated during the period October 24 through November 4, 1975. Production did not increase in one well and evaluations of the other wells were being performed.

24.

Contractor:	El Paso Natural Gas Company
Contract Date:	September 19, 1975
Anticipated Completion:	October 1978
Total Project Cost:	$4,761,000
Government Award:	$1,608,000
Type Project:	Massive Hydraulic Fracture

PROJECT STATUS

The first phase of the project has been completed. During 37 days of testing, 16.2 million cubic feet of natural gas was produced. The contract provides that under certain conditions two additional phases may be performed under supplemental agreements. No decision has been made concerning these additional tests.

25.

Contractor:	Kentucky-West Virginia Gas Company
Contract Date:	June 12, 1975
Anticipated Completion:	October 1979
Total Project Cost:	$229,500
Government Award:	$169,700
Type Project:	Directionally Deviated Wells and Inducing Multiple Hydraulic Fractures

PROJECT STATUS

A four-stage hydraulic fracture treatment was conducted on the Company's well No. 7239, Big Sandy Field, Perry County, Kentucky. Four 100-foot zones were treated successfully. Preliminary test results indicated that the reservoir pressure was very good, but that the deliverability was very poor.

26. Contractor: Tally-Frac Corp.
Contract Date: June 24, 1974
Anticipated Completion: Completed
Total Project Cost: $131,083
Government Award: $131,083
Type Project: Chemical Explosive Fracture

PROJECT STATUS

Detonation of 15,000 pounds of liquid explosives was successfully carried out on November 14, 1974. Final production tests on this well showed no improvement in production. A second well was also successfully fractured, however, the well showed no effect from the explosive fracture treatment. A third well was fractured and production was slightly improved over that previously experienced.

27. Contractor: Petroleum Technology Corp.
Contract Date: June 24, 1974
Anticipated Completion: December 24, 1975
Total Project Cost: $474,000
Government Award: $474,000
Type Project: Chemical Explosive Fracture

PROJECT STATUS

Detonation of 20,000 pounds of explosive was successfully conducted in two different wells in West Virginia. A third well in Virginia was detonated with 30,000 pounds of explosive. Production tests show no improvement in the West Virginia wells, and an increase in the production rate of the Virginia well.

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APPENDIX V

APPENDIX V

PRINCIPAL OFFICIALS

RESPONSIBLE FOR ADMINISTERING

ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		
ADMINISTRATOR:		
Robert C. Seamans, Jr.	Jan. 1975	Present
ACTING ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY:		
S. William Gouse, Jr.	Jan. 1975	June 1975
ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY:		
Philip C. White	June 1975	Present

ENHANCED OIL RECOVERY

Mr. YATES. Can you tell us how you plan to get to 800,000 barrels a day by 1985?

Dr. WHITE. That estimate is the total that we would expect that our adhering to the management plan on enhanced oil recovery would produce both by the work directly done by ERDA, but more importantly what was picked up by the industry. This comes onstream fairly quickly, not like gas within a few weeks, but within 2 or 3 years we are up to full production once we start. So even if it is not started until the early 1980's extensive application of it at that time can produce that volume of enhanced recovery.

Mr. YATES. What is your schedule for a gas recovery management plan?

Mr. WATKINS. This fall. We will not have a complete first draft by August, although we will have some of the critical strategy worked out by that time.

Mr. YATES. You expect that the increased price will enhance recovery of oil and gas?

Dr. WHITE. Very definitely. We will certainly reexamine the program, particularly once we know what the response is. It is conjecture at this point.

Mr. YATES. If the regulations come off as the President suggests, there won't be any need for Government funding then, will there?

Dr. WHITE. The technology and particularly the availability of the technology to the small producer is, I think, one of the critical outposts of the enhanced oil recovery program. That will still be a justification, I think, that may change somewhat as to the exact scope of the program.

Mr. YATES. Why was the budget increased by $12.6 million for enhanced oil recovery? You are not going to get much marginal benefit from that amount, are you?

Dr. WHITE. These are very heavily leveraged tests by and large. We have experienced as much as two-thirds industry funding, and they are not all that expensive, so $12 million leverage to increase our number of fuel tests is quite significant.

Mr. YATES. Do you want to place in the record the types of recovery techniques that have the most potential for short-term gains?

Dr. WHITE. Fine.

[The information follows:]

ENHANCED OIL TECHNIQUES OF SHORT TERM POTENTIAL

The FY 1978 Budget proposals for enhanced oil recovery address the four major enhanced oil techniques or processes which have the most potential for short-term gains. There are variations and combinations of these. They may be classified into two categories as follows:

I. Chemical Flooding
   (a) CO_2 Miscible
   (b) Micellar/Polymer

II. Thermal Flooding
   (a) Steam Drive
   (b) In Situ Combustion

A variation of the CO_2 Miscible Process entails the use of both water and CO_2 and is called the WAG process. A variation of the micellar/polymer process is the improved waterflood using polymer alone (with water).

The CO_2 miscible process and variations use carbon dioxide as a stimulating chemical to reduce oil viscosity and density and push it toward producing wells. Water may be used as the pusher.

The micellar-polymer process uses surfactants to release oil from sand pores, followed by polymer-thickened water to push the released oil toward producing wells. In some oil reservoirs the polymer-thickened water by itself may be effective.

Steam flooding is the continuous flow of steam from surface steam boilers to injection wells through the oil sands to producing wells. It applies largely to heavy-oil reservoirs in which oil-viscosity reduction by heat is essential. Without it, secondary - and even primary-oil production may not be possible. It may be most widely applied to heavy-oil reservoirs in California.

In Situ Combustion is a process of partial combustion under pressure in the oil sand itself by injection of compressed air. Part of the oil burns and the remainder, plus the combustion products, is driven toward producing wells.

The best application of these processes to specific reservoirs is a matter of scientific judgement based on incomplete technology. Criteria for selection of technology versus reservoir have been established. A full explanation of the potential for various enhanced oil recovery techniques including the assumptions involved in strategic planning are contained in the ERDA "Management Plan for Enhanced Oil Recovery" (December 1976).

CARBON DIOXIDE AND MICELLAR POLYMER PROCESSES

Mr. YATES. You are going to require large amounts of chemicals for carbon dioxide and micellar polymer processes. Are these in short supply?

Dr. WHITE. Yes; in terms of recoverable carbon dioxides, there are places where it is recoverable naturally. Gas wells produce gas that is largely or partly CO_2. Otherwise it has to be recovered from industrial sources, which of course are frequently in the wrong place as far as the gas fields are concerned.

The chemicals for micellar polymer flooding are of two types, the surfactant or detergent type materials, usually petroleum sulfonate which is somewhat limited in the country today, and the polymer type which thickens the water and drives the micellar solution in a uniform fashion. The polymers also are in somewhat short supply, so there will need to be, if this technology is adapted, increased chemical manufacturing capacity for both those materials.

Mr. YATES. How do you go about getting it?

Dr. WHITE. We figure that our field work will point out define the need. There will be a simple market response. We don't feel we have to do anything.

TERTIARY RECOVERY

Mr. YATES. Do you worry about the tertiary recovery? I read in the paper, and I am sure you did, about what happened to the aquifer in Oklahoma.

Dr. WHITE. I think I will ask Mr. Watkins if he will comment on that point.

Mr. WATKINS. That particular incident did not have anything to do with either an ERDA program or a tertiary recovery project.

Mr. YATES. Really?

Mr. WATKINS. That is right.

Mr. YATES. The newspaper indicated that it was tertiary recovery.

Mr. WATKINS. I am aware of that, but apparently it was a misquotation. This was near Oklahoma City and not anywhere near any of our projects. It was an aquifer contamination from salt water, evidently; although the report we got back was it was not connected with tertiary oil recovery projects.

Mr. YATES. Have you experienced any difficulties in connection with the tertiary recovery?

Mr. WATKINS. Not yet.

Mr. YATES. Did you anticipate any?

Mr. WATKINS. Sir?

Mr. YATES. You said not yet. Do you anticipate any?

Mr. WATKINS. No; we don't anticipate any, but we realize we live in the real world, and such a thing could happen.

ENHANCED GAS RECOVERY

Mr. YATES. That is right. We have got to go on living.

Enhanced gas recovery. You have increased your budget $11 million for this. Have you got a plan for enhanced gas recovery?

Dr. WHITE. Part of the program is in the Devonian shale. We referred to that as our Eastern Gas Shales Project. It is well developed in

terms of money going into resource evaluation, and largely spent through the university and state geological groups in the east, and then work on new stimulation techniques for the most appropriate resources.

This is pretty well developed. The places that are still in the developmental stage and will be part of this overall gas plan are the others, particularly the tight sands in the West, the Mesa Verde sand on the western slopes, the Rio Blanco area where the nuclear shots took place, the methane from coal seams, in which we are cooperating very closely with the Bureau of Mines. They undertake it as a safety precaution and we undertake it as conservation and gas supply measures, a sort of three-way program as an attempt to recover the methane, which is a very significant resource. Finally there are the geopressured aquifers on the gulf coast which are also of interest to the geothermal people.

We are trying to tie all of these together in proper coordination with the other groups in our overall plan.

Mr. McKAY. What about the tar sands?

Dr. WHITE. That is another factor. We do have one program going on tar sands in Utah. Our tar sands are much less attractive as far as the geographical locations are concerned. The deposits are not concentrated as they are in Canada. It is still one we feel we should pursue but it is a rather unattractive technology and so far hasn't produced very much.

Mr. McKAY. It hasn't?

Dr. WHITE. It has been very tough to get the gas out.

Mr. YATES. Is that because it is in Utah?

Dr. WHITE. No, sir, it is because the oil is very, very viscous and it is hard to get moving.

Mr. McKAY. I suppose you are working on an oil process. You would have to go to mining if you did it. There is this man who has got a solutionary process for it, press the sands and put in certain solutions and it works its way out. He has got a little table model I saw him working on.

Mr. YATES. You don't get much recovery from the table model.

Mr. McKAY. No; he has got to go to commercial size.

FUNDING PROCESS

Mr. YATES. Mr. Murtha?

Mr. MURTHA. Mr. Chairman, could I ask a question that is out of order, but about appropriations?

Mr. YATES. Shall we take a committee vote on it?

Go ahead.

Mr. MURTHA. About this funding, I am concerned that OMB and the two committees that I serve on have done the same thing in cutting out funds for projects that the agency felt were very important. The President obviously, and all of us, agree this is another priority. In MHD for instance this morning you talked about asking for $86 million and are getting $46 million. What happens in this process?

When you go over to OMB, do you set a series of priorities or do they just make the arbitrary decision they are going to cut 5 percent across the board?

Dr. WHITE. No; they are rather selective, and with the rationale that is sometimes more apparent to them than to us, but usually there is a good deal of discussion. For example the natural gas programs were increased. We actually came back from OMB with more money.

Mr. YATES. Geocells, too?

Dr. MANNELLA. There is a long, involved explanation. It took two trips to come out where we did.

Dr. WHITE. We always have the opportunity to appeal. We appeal those that we feel are most critical, and where perhaps their reasoning in our view has less persuasive than sometimes it is in other places.

Mr. MURTHA. Are you saying then in MHD in particular you didn't really press for the additional funding?

Mr. GREER. We appealed a portion of that cut all the way to the President.

Mr. YATES. All the way to the top. They went up to the President.

Mr. MURTHA. So the President is aware that this—

Mr. GREER. That appeal was to the Ford budget.

Mr. MURTHA. This was in the Ford budget?

Mr. GREER. Yes.

Mr. MURTHA. So this has not been appealed to the present administration?

Mr. GREER. No, sir.

Mr. MURTHA. But you do have an opportunity to appeal.

Dr. WHITE. The typical procedure is opportunity to appeal when we first get the pass back, and we appeal those. Again, there is not much point in appealing them all.

Mr. MURTHA. Yes, I understand. So obviously they just didn't feel that MHD was a justifiable project. It was not a priority.

Dr. WHITE. As I understand it, MHD has been subject to some political pressure. It really is a long-term program and it should move but at a reasonable pace.

DEVONIAN SHALE

Mr. YATES. Let's talk about Devonian shale that we find in Ohio, Pensylvania and other places along the east coast. You have a $5-million increase. You are going to get more out of the Devonian shale as a result of that. How much are you going to get by 1985, as an example? Do you have any estimates?

Dr. WHITE. I don't believe we are prepared to supply that.

Mr. WATKINS. Not for Devonian shale in response to the $5-million increase.

Mr. YATES. Can you get any gas from the Devonian shale using current techniques?

Dr. WHITE. There are places where it is highly fractured, like in Kentucky, where just conventional drilling will give you pretty good production, and there is a lot of production there. Some 9,000 wells are there.

Mr. YATES. Then you need the price rise recommended by the President?

Dr. WHITE. This will stimulate a lot of production.

Mr. YATES. What about the western tight gas formation?

Dr. WHITE. They are much less tractable to normal fracturing techniques than the Devonian shale and thus far there have been only limited success in really getting going.

Three nuclear fractures were essentially unsuccessful in producing any prolonged increase in flow. Massive hydraulic fracturing has been tried with only limited success.

Mr. YATES. Do you have any reason to be optimistic?

Dr. WHITE. Not terribly.

Mr. YATES. We are always optimistic.

Mr. WATKINS. I may say, Mr. Chairman, we have had some recent increases in production from massive hydraulic fracturing in these western type gas sands. How long those increases are going to be sustained is something we have yet to determine.

Mr. YATES. Is this in Utah, too?

Mr. WATKINS. Yes, Colorado, Utah, and Wyoming.

Mr. YATES. It is awfully tight in Utah.

Mr. MCDADE. You are referring to the Devonian Eastern when you say you are not optimistic.

Dr. WHITE. No, this is Western. It is quite different.

Mr. MCDADE. Have you got enough money in this budget to do what you want in the Devonian shale?

Dr. WHITE. Oh, yes.

Mr. YATES. The only thing he doesn't have enough money on is MHD.

Mr. GREER. The pending budget amendment will include additional funding for Devonian shale.

Mr. YATES. When?

Mr. GREER. Next Monday is the latest date we have heard.

Mr. YATES. You want another $5 million for that?

Mr. GREER. Yes, sir.

Mr. YATES. Will that be adequate?

Mr. GREER. It is all we asked for.

Mr. YATES. It is all you asked for?

Dr. WHITE. Yes.

Mr. YATES. You do know you can recover from Devonian shale.

Dr. WHITE. Oh, yes.

Mr. YATES. You don't know whether you can make any recovery from the Western tight gas reserves.

Dr. WHITE. Whether we will be able to have a technology that will be commercially attractive from Western tight gas sands, we simply don't know yet.

RECOVERING METHANE

Mr. YATES. You have a program for recovering methane from coal seams. The Bureau of Mines has got a program, and you also have a conservation part.

Dr. WHITE. We are trying to keep that very closely coordinated.

Mr. YATES. Let the record show that Dr. White clasped his hands together and showed how tightly that he is cooperating with Dr. Mannella and with the Bureau of Mines.

Dr. WHITE. Will you back me up, Gene?

Dr. MANNELLA. Absolutely, positively.

Mr. YATES. Now you want to recover methane from geopressured aquifers. Is that a potential resource?

Dr. WHITE. This is a resource which the USGS has published figures on, which are literally staggering. There is rather meager data on this resource, which underlies a good part of the gulf coast of Texas and Louisiana. There is very clearly a lot of gas there. It is saturated in brines that are locked in at high pressure and temperatures of 300 to 350 degrees F. It has geothermal energy in that brine, heat and pressure as well as the gas, but the gas is the largest amount.

Therefore, it is a program on which we are working closely with the Geothermal program, but we are just producing now the first flowing well in that type of formation, and we don't have any data yet.

IN SITU GASIFICATION

Mr. YATES. Now let's talk about in situ gasification, the long-term program.

Dr. WHITE. Yes, I think this will come slowly. It is easy to do it experimentally and have an installation working. We have had very good success last summer with a program near Laramie, Wyo. The problem is, of course, it is not near the markets, and there are two critical environmental problems which have yet to be really scoped. One is the matter of subsidence of the ground surface because you have burned up a good part of the lower seam, and the other is potential aquifer contamination because the ash remaining would be leachable where the coal is not. You may find later that ground waters were contaminated. One of the major purposes of this summer's program is going to be to check that aquifer.

Mr. YATES. Why do you need four separate processes going at the same time for this?

Dr. WHITE. There are really different beds, different depths and different types of depths. The one we had good success with the so-called linked vertical well, is clearly operable for a uniform bed. The steeply dipping beds are, as the name implies, adaptable to the ones which are above 45 degrees pitch.

The packed bed concept is simply an alternative to the vertical well, which is the most economic, and the long wall generator is really adaptable to some of the ones in the East where you have got a very thin seam. I would have to guess at this point. This one may drop out. It is a tricky one where you drill down and go along the coal seam.

Instead of taking two wells down and going this way, you have two going across like this. If you learn how to do it, the two wells could open up lots more coal that way than two going down vertically, and also it would be adaptable to less permeable coal.

LINKED VERTICAL WELLS PROJECT

Mr. YATES. What is the status of the linked vertical wells projects?

Dr. WHITE. We will be starting the third and fourth tests within the next few months. These will be relatively small scale. One of the things that I think is going to be quite helpful is that a subcommittee of our general technical advisory committee which has been advising the fossil program for years has been asked to look at this program and

recommend what we do. Their recommendations have been quite clear cut, that the most important thing to do is a large single field, to take the vertical well and do it in a big enough area to produce enough gas to really show it can be done to support a utility power generation operation.

Mr. YATES. Do these processes have environmental hazards?

Dr. WHITE. Yes; the two I mentioned, subsidence and underground water. You have to clean up the gas at the top, but that is no worse than any coal gasification.

Mr. YATES. How do they compare with regular mining and strip-mining?

Dr. WHITE. There is clearly less chance of having a major reclamation problem. The economics would be much more favorable. The hazards to miners are absent and it should be more attractive.

Mr. YATES. Now we turn to conservation, and Dr. White relaxes a little bit.

Dr. WHITE. You would like me to stay, however?

Mr. YATES. Oh, yes, just as Mr. Mannella is backing you up, I am sure you will want to back up Dr. Mannella.

Dr. Mannella, how are we doing in the field of conservation? Can you give us an overview of it?

Excuse me, if you want to ask Dr. White a question.

Mr. MCKAY. Yes.

Mr. YATES. All right.

OIL SHALE PROGRAM

Mr. MCKAY. I have some information that depending on how you proceed with a program, for example, TVA's debt financing process, you maybe could produce out of shale, for example, depending on which kind of a financing operation, like the oil companies and their equity financing process, you could maybe come up with oil shale at $11 a barrel or $11.41. That would be the TVA process; $19 a barrel with the equity financing way, or if they got a loan guarantee, it could be as low as $12 a barrel. Has that been taken into account in our discussion?

Dr. WHITE. Yes. Generally when we talk of the typical shale plant, we have been talking 100 percent equity finance figures.

Mr. MCKAY. That would take it up to about $19 a barrel.

Dr. WHITE. It depends on which process you are talking about. This is talking about the aboveground retort process at $19 per barrel, but I think if you took the modified in situ like Occidental is talking of, and still talking 100 percent equity, it is $11 to $13 a barrel.

Obviously there is great leverage on how you finance, whether it is 100 percent or partial, and whether it is 100 percent loan guarantee.

Mr. MCKAY. If you got a loan guarantee on the total capitalization you could probably bring it out at $12 a barrel, is that what you are telling us?

Dr. WHITE. Yes; it will come down. The physical costs aren't going to be any different.

Mr. MCKAY. Would there be some advantage then in the Federal Government going into a loan guarantee situation on the original capital investment on that, to get those kinds of prices? It wouldn't be bad, rather than to force the price up to $19 or $20 a barrel.

Dr. WHITE. I am not any finance expert. It would seem to me that there is a certain anti-inflationary impact by having loan guarantees

to keep the price down. Maybe there is something about the financial aspects that I am not sophisticated enough to understand that would offset that.

Mr. McKay. But the items I am giving you here as operations that relate to finance, they are viable.

Dr. White. Oh, yes.

Mr. McKay. In accordance with our previous discussion about the technology as related to the financing of getting it started so that the technology itself, if you have got the guarantee on the capital investment or some form of it, could be within range where you could get started right away.

Dr. White. Yes.

Mr. Long. Will the gentleman yield.

Mr. McKay. I yield.

Mr. Long. I am very leery of these subsidies and guarantees, because it always seems to me that they go to the wrong things, and once you get it into any area it stays there, even after the realities call for a shift.

Now, it is my understanding, when I was talking to the people at Paraho and when we had the people from Occidental here before us—that is the name of it, isn't it, Mr. McKay—that there was a willingness there to go into this thing without subsidy, without guarantees of any kind, provide only that they were guaranteed against what I thought was a very reasonable thing; namely, that we wouldn't put a ceiling price below what the $11.50 is now, and that we wouldn't come in with an awful lot of environmental changes that would make the environmental requirements very different than now.

Why are we talking about loan guarantees and subsidies in this business?

Mr. Yates. There aren't any since there is no authorizing legislation.

Mr. Long. I understand, but we are talking about them here, aren't we? Why should we be talking about that?

Dr. White. I was trying to respond to Mr. McKay's question about the arithmetical impact, the loan guarantee on interest rates does do this for a project that is proposed on that basis.

Mr. McKay. There is one other question in connection with this. The White River Shale, for example, they indicate that they originally estimated that they could move to 100,000 barrels per day oil shale plant in about the $600 million range and that has now escalated to about $1.5 billion, which is about what you said, but that was for 100,000 barrels and you were talking about 50,000.

Dr. White. Yes.

Mr. McKay. Are they wrong?

Dr. White. No.

Mr. McKay. Or is this something else they are talking about?

Dr. White. There are advantages of scale in these large retorts. I think we are a little shaky on just what they are yet since they haven't been built.

CONSERVATION ACCOMPLISHMENTS

Mr. Yates. Dr. Mannella, can we find out from you what we are doing in conservation? Have we advanced substantially, perhaps tremendously, since last we met last year?

Dr. Mannella. In terms of our program, Mr. Chairman, I think we have some important successes that we can talk about.

Mr. YATES. Not including, however, the fluorescent light bulb?

Dr. MANNELLA. That is not yet in the success category, that is correct.

Mr. YATES. What successes have you had, Doctor?

Mr. DUNCAN. Or the intertial storage system on the automobile.

Dr. MANNELLA. That remains to be seen. We hope that that will be a future success. We have had a number of programs that I think can be looked upon as sort of the precursors of making a substantial impact in the market. In the buildings and community systems area, we have broken ground for a plant at Pompano Beach, Fla., which is designed to convert municipal solid wastes to methane. If that methane tests out to be pipeline quality, it can be added to the pipeline system, and we hope that this would be the precursor of a number of these kinds of plants.

Mr. DUNCAN. Would you yield?

Is that by tapping old fills or is it by conversion of current wastes?

Dr. MANNELLA. Conversion of current wastes. We have been operating in conjunction with a restaurant chain, a fast food restaurant in the Albany area. These are particularly wasteful users of energy, and we have worked with them to put in some technology that would enable this type of unit, this type of restaurant, to conserve considerable amounts of energy.

The results of that are becoming available now. The chain indicates that they are planning to use this kind of technology in all of the units that they open up, and furthermore——

Mr. MCKAY. What is the technology?

Mr. DUNCAN. Turn off the lights.

Dr. MANNELLA. The technology involves such things, for example, as using some of the waste heat from some of the mechanical systems to help preheat the water for washing the dishes and utensils, and similar internal operations of the restaurant.

Mr. MCKAY. A hood over the frying pan?

Dr. MANNELLA. Yes; you capture some of that heat and use it to preheat the dish washing water, things of this sort. The industry is very interested in this, and we hear that some restaurant chains may be thinking of retrofitting all of their units to use this kind of technology.

FUEL-SAVING SYSTEM FOR PAINT CURING

In the industrial energy conservation area, we had a very successful demonstration this past winter out in Indiana with a company called Rollcoater. This is, I believe, the largest industrial firm that coats large rolls of steel with paint or plastics. This material is used to make refrigerators and similar appliances.

Normally, in the process this material is coated and is then run through a very, very long oven, where gas is used to dry the paint Then additional gas is injected in the top of the unit to burn the fumes from the paint, in order to meet the environmental standards.

We modified that furnace to take the fumes driven off the paint, and feed them back into gasoline that fires the furnace and dries the paint in the first place. We have reduced the amount of natural gas used in that operation by 80 percent, and we understand that this technique will be fairly standard throughout the industry in the next several years.

Mr. McKay. How many years?

Dr. Mannella. It depends on the rate at which the other companies acquire these units, but as a result of this operation we understand that there are any number of companies that have already placed orders for the equipment now.

Mr. Yates. How do you spell Rollcoater?

Dr. Mannella. R-o-l-l-c-o-a-t-e-r.

Mr. Yates. Just like it sounds.

Dr. Mannella. Just like it sounds, that is right. Doug, where is that located, do you know?

Mr. Harvey. Greenfield, Ind.

Mr. McKay. Are there mandates for retrofitting any of this?

Dr. Mannella. No; there are not, but I am sure there will be a surge of interest and orders as a result of the very bad situation we had last winter.

Mr. McKay. How about the time frame for this?

Dr. Mannella. At the present time I think the experience of many manufacturing outfits in that part of the country is that they are very actively looking for ways to either cut down their natural gas usage or to get off natural gas.

Mr. Yates. I am not sure I understand that Rollcoater operation.

Dr. Mannella. It is both the name of the company and the process. That may be a little confusing.

Mr. Yates. It isn't the company that painted the steel?

Dr. Mannella. Yes.

Mr. Yates. In conjunction with you, it developed this quick-drying process.

Dr. Mannella. It is a modification of the existing furnace that has been used throughout the industry for many, many years. Normally they take these very, very large rolls of sheet stock, usually sheet steel, and they spray it with paint and run it through a very long furnace to dry that paint. The drying action takes place because the furnace is gas fired and you have a hot environment in that furnace.

Furthermore, in that particular process, because the paint fumes did not allow the company to meet the ambient air quality standards, they had what amounted to a second burner on top of the furnace, to incinerate those paint fumes and break them down into carbon dioxide and water.

We modified the furnace so that we took the paint fumes that were driven off and fed them back into the natural gas lines that fired the furnace, and essentially burned the paint fumes in the furnace to help dry the paint.

Mr. Yates. You say we did it?

Dr. Mannella. ERDA did this in cooperation——

Mr. Yates. How did you do it? Did you contract for somebody to do it or what?

Dr. Mannella. Yes; we did.

Mr. Yates. What was your process?

Dr. Mannella. We had a contract with the company and also the National Coil Coaters Association, which is their trade group, was involved. The agreement was that we would go in, modify the furnace and they would operate it, collect the data as a demonstration of how this technique might significantly reduce the amount of natural gas required in this type of drying operation.

Mr. YATES. If it works in this industry, would it work in an industry such as the furniture industry, which does so much drying of furniture.

Dr. MANNELLA. We are looking at other industries. There are two basic ways of painting or processing this kind of material. One is where you prepaint, like you do for refrigerators. Here you have these coils of prepainted steel delivered to the manufacturer, who stamps out the parts.

The other technique is to postpaint. Here you make the product like an automobile and then paint it.

We are looking at all of the painting operations, both prepaint and postpaint, to see if we can adapt some of this basic technology to saving energy in those other areas as well.

I don't recall whether or not we have looked at the furniture industry. Have we, Doug?

Mr. HARVEY. No, sir, we haven't.

Mr. YATES. I remember having seen furniture being made. They paint and then put it through the ovens to dry the paint or dry the varnish or whatever.

Mr. Duncan?

Mr. DUNCAN. I just went through a barrel plant in Portland the other day. They have reduced their gas consumption by a prodigious amount by reducing the temperature in their dryer, and extending the conveyor belt out to 2½ times its former length before it got to the trucks, so there is a lot of air drying that takes place, and it is eminently satisfactory. They reduced the temperature down, I think, 300° of 400°.

Dr. MANNELLA. You can do that if you don't have any problem with solvent from the paint. In the barrel plant they are using a water-based paint. Also the quality of finish is not that crucial in a 55-gallon drum as opposed to stock that would be used for appliances and things of that sort.

Mr. YATES. So far you have given us a success story.

Mr. DUNCAN. Any more?

Dr. MANNELLA. Yes; we have a few more.

Mr. YATES. How much did you spend on this experiment?

Mr. HARVEY. The total program for the coil-coating program is $900,000, of which ERDA's share was approximately $400,000. The three other participants were B & K Industries, who produced the equipment with which the furnace was retrofitted, Roll Coater Corp. and the National Coil Coaters Association, who put in the other 60 percent of the money.

Mr. YATES. How do you hear about this? Does B & K come to you?

Dr. MANNELLA. In this case we were contacted I believe by the National Coil Coaters Association. They came to us and said, "We are very concerned about the dependency of our industry on natural gas," and they were quite willing to engage in activities of this sort with us, and we sorted through and picket out the ones that we thought had the highest potential for success.

DEBONING OF BEEF PRODUCTS

Mr. YATES. What is the next item under consideration?

Dr. MANNELLA. We have a project with Oklahoma State University where we are working with them on the hot deboning of beef. This is a project which would considerably decrease the amount of refrigeration that is required in processing slaughtered animals from the slaughterhouse to the supermarket.

The problem here is whether or not in this type of process the quality, texture and taste of the product competes with that through the normal process, where it ages to a certain extent on the hook in the freezer.

We had a little demonstration here several months ago, where Oklahoma State University came in and had what amounted to a little beef tasting panel up here on the Hill with the Oklahoma delegation and had both the conventional beef and the hot deboned beef for people to try. This looks very promising, also.

Also, it looks like it may be quite possible to control the flavor and the quality of the product and decrease the amount of material that has to be refrigerated and transported by approximately 60 perecnt of the weight.

Mr. MCKAY. An awful lot of heat is expended from the point of the slaughtered animal for refrigeration to bring that temperature down to where you can set the meat where you can start working. At this point, they debone it.

Dr. MANNELLA. They debone it on the rail.

Mr. MCKAY. As it comes off the kill?

Dr. MANNELLA. That is right. There is one thing that you have to do, which is where the quality control comes in, to convert it from muscle to meat. Normally when you let it hang certain chemical processes take place.

Mr. MCKAY. Enzymes?

Dr. MANNELLA. Enzymatic action. On the rail you do this by passing a small electrical current through the carcass. These are the parameters that we are struggling with right now.

Mr. MCKAY. You save some electricity but then you have got to use some more for the shock.

Dr. MANNELLA. I think it is relatively modest, compared to the amount that would be consumed in running the refrigerating plants plus the trucks and refrigerated railroad cars.

Mr. MCKAY. You are eliminating that week to a 10-day period.

Dr. MANNELLA. Waiting period.

Mr. MCKAY. So you get that tender steak that these guys always like.

Mr. MURTHA. What happened in this test with the Oklahoma delegation?

Dr. MANNELLA. I can only kind of give my own personal reaction to it. I thought the product was quite acceptable. On a side-by-side comparison it was not quite up to the conventional supermarket product. I think without the side by side, I doubt whether I would have been able to tell the difference, but in a side by side, it is not quite there, but I think it is just a matter of working out some more of the details of the exact process.

Mr. MCKAY. You are not used to eating less tasty tomatoes where a similar process is used.

Mr. McDade. Mr. Chairman?
Mr. Yates. Mr. McDade.

CONSERVATION EFFORTS OF DOD

Mr. McDade. Generally the Department of Defense has a broad exemption from restrictions on natural gas curtailments.

Have you authority to examine in the same kind of way their contractors, or if it is a depot, their depot activities with a view toward conservation efforts as well?

Dr. Mannella. We have authority in the sense that we are a research and development agency, and can look for and engage in opportunities to save energy without any constraints that I am aware of. Whether or not that authority would extend beyond that, having developed something, I don't think that is the case.

Mr. McDade. I believe it is correct that if it is a contractor operating for DOD, and you get into a curtailment situation he gets an exemption and can use the gas that he needs to do whatever it is he is doing, and there isn't much incentive on the part of that particular contractor or group of contractors as there would be on the part of coil manufacturers, to come to you and say "Look, if we can work together, maybe we can do something." I was just wondering if we have a little segment that needs some kind of special attention to make sure that the contractors have an incentive to try to get together with you and work out anything.

Dr. Mannella. That may be a good point to keep in mind. I think that one of the benefits, as it were, of the rather terrible past winter is that many of the industrial users of natural gas have developed a somewhat different attitude toward the economics of energy conservation. Energy conservation competed very poorly for industrial dollars relative to other options, such as expansion, advertising and what-have-you, because they were looking at very cheap natural gas, but when you are looking at no natural gas at any price, energy conservation begins to compete much more effectively, and the thing that you are referencing here perhaps is something that we should look into.

Mr. McKay. Will the gentleman yield?

In the military construction budget which I chair, we have been after the military as to what they are doing with conservation measures. In some areas they have orders to prepare for alternatives from either oil, gas, or conversion to coal, in their new plants that they are putting in in some areas.

Have they ever contacted ERDA to assist them in the knowledge they might have to bring up to date their conservation method?

Dr. Mannella. Yes; we are working with several elements in DOD. We are working with DOD on a very, very large installation with many thousands of people, both military and civilians at Sewell Point, and we are working with them on an overall conservation plant for the entire complex.

CONSERVATION IN INSTITUTIONAL BUILDINGS

Mr. McDade. What is your authority with respect to hospitals, for example? Ever since this thing has started, I don't think I ever

walked into a hospital to visit patients where it wasn't absolutely stifling. I don't know whether they need it that high.

Dr. MANNELLA. Institutional buildings, which is what we tend to describe as hospitals, schools, and a number of groups like that.

Mr. MCDADE. There is no special category for hospitals or institutional buildings.

Dr. MANNELLA. That is one of the prime objectives we have in 1978 in developing minimum industry standards. One of the things we would like to look into is some of the ventilation requirements for hospitals. We think that they are based on rather archaic principles, and there are enormous amounts of energy used to circulate air perhaps much more often than it has to be. With better filtering techniques you can possibly cut down some of that.

ENERGY CONSERVATION FOR OFFICE BUILDINGS

Mr. YATES. What are we doing for all the huge buildings that are air-conditioned that have been designed under construction that requires heating and air-conditioning without being able to open windows?

Dr. MANNELLA. We are developing building controls that will control the climate in a building a little better and more automatically. Such building controls can turn things off and on in anticipation of a building energy load increasing. You come into a building in the morning it is one temperature. You fill it up with people. These are essentially minicomputers that can run a building for you much more effectively. There are a whole set of architectural design and standards some of which we are testing for example in the Federal office building in Manchester, the Norris Cotton Building. There are a number of different technologies there. The lighting in a building does not have to be uniform, which is the quickest and easiest type of thing to put in. You don't need as many lights near the windows as you do in the interior of the building.

The siting of the building, the use or nonuse of windows, all of these things can be cranked into the architectural design of the building, and in many cases any additional cost that is involved in this process can be offset by the fact that your mechanical system can be sized down a little bit. You don't need as big an air-conditioning system or as big a heating system or you don't need as much energy for lighting a building.

Mr. YATES. What do you do in a building like this? This building is heated and air-conditioned automatically in the summertime. It may be on now. There are windows there that open. They have never been opened.

Mr. MURTHA. We use coal, Mr. Chairman. It is all coal fired.

Mr. YATES. I don't know about that but they are air-conditioned.

Mr. MURTHA. But they are coal fired. The energy is coal.

Mr. YATES. Are you sure of that?

Mr. MURTHA. All the Capitol complex is what the Architect told me, coal fired.

Dr. MANNELLA. Your point is a good one, Mr. Chairman.

Mr. YATES. Let's take the Federal building in Chicago.

BUILDING STANDARDS FOR COMMERCIAL BUILDINGS

Dr. MANNELLA. The first target in the commercial area is to develop standards for the new buildings and to convince the architects and the building owners that it is economical to design conservation in the building from the start, either economical in terms of first cost or life cycle costing. Retrofitting is not quite as easy and as straightforward.

We have two well-known building firms, Sisca and Hennessey & Tishman Associates in New York City doing a broad study of some 900 existing office buildings and a detailed study of 44 to see what actually can be done in terms of retrofitting in buildings of that type. We really don't have the answer to the retrofitting of the buildings yet.

Mr. YATES. When did the study start?

Dr. MANNELLA. The study is underway. It started last year.

Mr. YATES. When will it be completed?

Dr. SAVITZ. The study was started last year for data on office buildings in New York City to analyze the energy usage and as a function of the type and age of construction. The data is due in June with recommendations as to what type of retrofit measures might make sense beyond simply cutting off lights and turning down thermostats.

Mr. YATES. There is no compulsion at all. Is there a compulsion about not supplying natural gas for these buildings?

Dr. MANNELLA. I suppose that would be effective.

Mr. YATES. Is there any compulsion at all? I know of nothing in the law now or in the regulations that requires them to seek—by "them" I mean building owners—to seek methods of cutting energy use.

Dr. MANNELLA. As far as commercial buildings are concerned, the operators of commercial buildings are generally sensitive to cost. As cost of energy goes up I think they will be more and more stimulated to look into this.

Mr. YATES. Unless they pass them on to the tenant.

Dr. MANNELLA. This is a possibility.

Mr. MCKAY. And also if it is a contractor who builds to sell, he sells a building for looks and utility, not necessarily for its cost of energy.

Dr. MANNELLA. In the new building, we will hope to cover them with our minimum energy standards that we are working on with HUD.

Mr. MCKAY. Have you got any State or National building codes that apply to energy saving devices?

Dr. MANNELLA. What we are doing, we have developed the model code, and we are working with the National Conference of States on Building Codes and Standards referred to as NCSBCS. We are very encouraged that they seem quite willing to perhaps adopt our model code as a standard code for the entire country. This would help solve the problem of different jurisdiction, cities and States having different model codes, and industries and suppliers and component developers trying to satisfy many different markets. You would have one standard code for minimum energy requirements perhaps in the whole country.

INDIVIDUAL ENERGY METERING

Mr. MURTHA. Another proposal in line with what the chairman said is a proposal that they be individually metered, each of the

tenants in the commercial building, so that they would pay their own heat bills which would be an additional incentive. They would have the incentive to cut back.

Dr. MANNELLA. In multiple family housing units, individual metering is very attractive. Then there are extensions of that for residences, for something that we call a money meter which is essentially a meter that tells you not how many watt-hours you have used but how much your bill is going to be. These are some of the things that we are testing, but the other portion——

Mr. MURTHA. Don't they project a 30-percent saving in energy in an apartment complex if they put in individual meters?

Dr. MANNELLA. That is consistent with our figures. We think that the energy use in commercial buildings can be cut 50 percent, and in residences cut 30 to 33 percent.

ENERGY USAGE IN METALS INDUSTRY

Mr. DUNCAN. Mr. Chairman, could I get him on just a slightly different angle? I went through a small steel plant at Portland.

Mr. YATES. You were busy.

Mr. DUNCAN. I watched them pouring hot ingots in their molds. Then they would stack them out to cool. Just outside the foundry they had a rolling mill, and they would haul these cooled ingots from where they would start them over and then heat the bloody things up again. I never could figure out, and I couldn't get an answer from anybody, from the manager of the company down to the foreman on the floor, why they couldn't take the hot ones and start rolling them. I understood they would have to have an inventory on hand perhaps for special orders, but it just looked like a prodigious waste.

Mr. LONG. I noticed the same thing at Sparrows Point. It is the largest steel plant and one of the most modern in the world, 10 million tons a year, and they do the same darn thing, a horrible waste.

Mr. DUNCAN. What is the answer to that?

Dr. MANNELLA. This is fairly characteristic of the metals industry, not only steel but other heavy metals industries, too. They seem to have an extreme reluctance to go into a continuous process. A continuous process is more difficult to control. You have to control it at all stages from when you first make the metal all the way through to when you finish it, and if anything goes wrong in any part of the process, if you are not careful, the whole process shuts down. So for convenience, it is attractive to make a batch intermittently. You make the ingots here, pull them off, heat them up again, roll them, cool them down. You heat them up again.

Mr. DUNCAN. There is no metallurgical reason why that has to cool first.

Dr. MANNELLA. None that I am aware of. However, we have been quite interested in the continuous casting of steel, the energy cascade, where you cut out this intermediate heating and cooling step, which has been done at least on some scale in Europe, and where they do seem to have some better technology or at least are willing to become acquainted with continuous processes of this sort.

In certain industries like the chemical and petroleum industries, continuous processes are simply a way of life. They have grown up with them, lived with them, they know how to control them. They

know how to handle the intermittent breakdowns, but the U.S. steel industry seems to be very reluctant to try this. We have been talking to various steel companies for the better part of a year now about the possibility of developing some sort of joint program for demonstration on continuous casting of steel, and we have not made an awful lot of progress on this.

Mr. LONG. Part of the problem is when the steel plants were built, the plants were for some reason put pretty far apart, so there is quite a transportation of the hot pig iron ingots or whatever you call them. You have to transport them quite a distance over to where you have to reheat them to go through the rolling mill, and they would have to spend an awful lot of money I guess to build new mills and relocate them closer.

Dr. MANNELLA. That is exactly right. The capital requirements would be extremely high, and it is still cheaper to buy the additional energy and use it.

STRATEGY OF ERDA'S CONSERVATION PROGRAMS

Mr. YATES. Dr. Mannella, it suddenly occurs to me that you have got a tremendous, enormous job. I look at your justification and I see it broken down into three main parts: industrial energy conservation, building and community systems, transportation energy conservation, and there is one more I think.

Mr. MANNELLA. Energy conversion technology.

Mr. YATES. That is right. And then under No. 1 for example, industrial energy conservation, you have waste energy reduction and utilization, industrial process efficiency, agricultural and food process efficiency, technology transfer, industrial impact analysis.

How do you know about all the industries in the country? How are you organized? What kind of organization do you have in your conservation department? Who knows about chemicals as opposed to furniture, as opposed to the soft drinks industry, as opposed to the hundreds of different kinds of industries that there are? How do you keep track? How do you propose to know what is going on in the entire industrial complex of the United States?

Dr. MANNELLA. It is quite a difficult problem and quite a challenge. It varies from area to area though. For example, what we have done is to develop a strategy in each of the three traditional end use areas that you just discussed. In the transportation area, for example, because of the fact that highway vehicles consume 75 percent of the transportation energy, all of this petroleum, an amount of energy about equivalent to that which we use to heat our homes, because the fleet turns over every 10 years, our strategy is to develop a much more efficient heat engine for automobiles, 50 to 60 percent more efficient than that which we have today, or to replace some significant part of the fleet with electric vehicles.

Mr. YATES. What do you mean by heating; an engine?

Dr. MANNELLA. An engine that would burn some fuel, go through a heat cycle, and drive the vehicle.

FUEL ECONOMY OF AUTOMOBILES

Mr. MCDADE. Can I stop you just right there for a second? Everybody talks to me about automobiles and says the key is weight. You

just reduce the weight and you have got more miles per gallon, and that is it.

Dr. MANNELLA. There is no doubt that over relatively short ranges that there is virtually a 1–to–1 relationship between weight and fuel consumption. If you drop the weight of a vehicle about 5 percent, you will drop the specific fuel consumption about 5 percent, and in terms of highly efficient engines for small cars, we really have no problem. You can buy now or will be able to buy in the next few years vehicles in the 2,000-pound class with very highly efficient 4-cyclinder engines that will get you 40 miles to a gallon.

Mr. MCDADE. What is a 2,000-pound, a subcompact?

Dr. MANNELLA. Yes. The problem is that vehicles of that sort cannot possibly serve for our total fleet needs; 23 percent of the families in the United States have five or more people in them. We have a whole section of society that really does require a bigger car, a station wagon, a van or a pickup truck or something of that sort, and we need a very efficient engine in the 150 to 170 horsepower range in order to complement these very efficient small cars we have.

Mr. MCDADE. How much do you contemplate spending on a program like that over the next 10 years?

Dr. MANNELLA. Our plan calls for the following: We will pursue, jointly funded with industry——

Mr. MCDADE. Fifty-fifty?

Dr. MANNELLA. Not exactly It depends on the negotiation. We will pursue the Stirling engine, and the turbine engine in parallel out to about 1981. At that time we will make a decision as to which one of those is the most promising one for commercialization. The engine will be developed for a couple of years, and subsequently it will be turned over to industry for mass production by 1986 or 1987.

Now the total cost to develop a heat engine to that stage for an automobile is about $150 million, and our crash program is probably going to be more like 70–30 for various reasons, and so we would carry at least one of the programs through to completion and one of them through at least half to completion.

Mr. MCDADE. My memory tells me we had a statement in front of the committee that Detroit argues that the problem is not technology, that they can give you the miles per gallon that you want. Their problem is one of marketing. I assume that ties into your statement.

What you mean is that everybody can't drive a Chevette.

Dr. MANNELLA. That is exactly right.

Mr. MCDADE. From the standpoint of Detroit you would interpret their statement if I remember exactly, that you need a much larger car for much larger purposes as you go down through the market to larger families, different-type vehicles, et cetera.

Why do you have to spend that $150 million or any part of it?

R. & D. BY AUTOMOBILE INDUSTRY

Dr. MANNELLA. For the simple reason that industry will not. The Ford Motor Co. has gone on record before the Congress saying without the involvement of the Federal Government there will be no Stirling engine in the United States. They hold the patent rights for the Phillips engine which is the most promising Stirling technology.

Mr. McDade. This is penny ante money to these fellows. I don't understand what is going on here.

Dr. Mannella. It is not all that small. They are mounting and spending a massive amount of money in meeting the mandated minimum energy standards now, the 27.5 miles per gallon by 1985. They are sizing down, redesigning all of their vehicles. They are spending a considerable amount of money on emissions control technology, safety technology, and what have you. The fact of the matter is when you look at their budgets, the amount of money that they are spending on creative engine technology is either very small or zero, in spite of the fact that they claim to spend up to $1 billion a year.

Mr. McDade. And the reason in your judgment is just inertia? Industry inertia?

Dr. Mannella. No; I think that even given the size of the automobile industries, that they have such demands that a high-risk program, such as this, and this is a high-risk program——

Mr. McDade. Why?

Dr. Mannella. It requires high-risk, high-potential payoff technology to gain the efficiency which is potentially available from operating these engines at extremely high temperatures. In thermodynamics generally speaking the higher the temperature the higher the efficiency. To get this very high efficiency you have turbine inlet temperatures of 2,500 to 2,600 degrees Fahrenheit. That is going to require some new ceramics technology, and it remains to be seen whether or not we can come up with an engine with either all or many ceramic parts that can operate in this temperature regime, be mass producible, economically competitive, and last 50,000 to 100,000 miles.

Mr. McDade. With this cost sharing of Federal money, are all the "Big Three" going to have the same engine in them?

Dr. Mannella. No. We are developing the turbine engine with Chrysler, the Stirling engine with Ford, and have virtually nothing with General Motors.

Mr. Duncan. Would you yield for one question?

Mr. McDade. Sure.

Mr. Duncan. Didn't industry invest $150 million in the Wankel without any Federal help which has just gone belly up?

Dr. Mannella. That is correct; $60 million was put into a plant to produce Wankel engines which has not and never will produce an engine.

Mr. Duncan. They have made these investments.

Dr. Mannella. That was not a particularly wise investment because the bulk of the scientific opinion at the time was that the Wankel could never be made efficient, that it was a dirty engine, and would never actually be producible in the size range that they were designing.

GAS MILEAGE OF AUTOMOBILES

Mr. McDade. Let me take you back now. I have I don't know what mileage, very little, a station wagon that I drive. I have four children. You are telling me that if what you are doing succeeds you get this very high heat engine, that it is going to look forward to 30, 40, 50 miles to the gallon?

Dr. Mannella. Depending on the size of the station wagon. They get pretty big. What we are saying is in about a 3,500-pound car,

which is sort of the baseline kind of car that we are trying it to, we have our prototype turbine engine just now installed in a Dodge Aspen. We think that is the kind of envelope, a rather boxy sort of silhouette that is going to be rather typical in the 1980's for family sedans. We will be testing this baseline engine this fall. For a wagon it is going to be bigger, it is going to be heavier.

Mr. McDade. What does the Aspen get now?

Mr. Brogan. The Aspen wagon, the 6-cylinder——

Mr. McDade. It doesn't have to be a wagon, the car he is talking about.

Mr. Brogan. I believe it is about a 3,500-pound weight. They are getting about 18 miles per gallon on the composite cycle.

Mr. McDade. Assuming that everything you are hoping comes true, we are all hoping comes true.

Dr. Mannella. About 27 miles per gallon. The initial engines going into production may not have the 50 percent increase because these engines would be upgraded during the course of their production. Industry indicates about a 30 percent improvement would be sufficient to commit to production because their experience shows during the course of production, through evolutionary improvements you can increase that significantly.

Mr. Yates. Dr. Long?

Mr. Long. I bought two cars in the last year.

Mr. Yates. Oh, you sold your farm?

Mr. Long. No. One car had done 175,000 and there came the time when I decided probably it was wise to turn it in.

Mr. Duncan. Had the isinglass curtains worn out?

Mr. Long. It was a 1971 Buick, and I drove it a lot of mileage back and forth to Baltimore every day. I bought a station wagon for my wife because her car had a lot of mileage on it. I went into a lot of this stuff. I went at it from the standpoint of price, consumer psychology and all that.

Mr. Yates. Did you talk to Mr. Brogan about it?

Mr. Long. No; I did not. He is one of the few people that I didn't talk to. Here is my impression. An awful lot of small cars will hold as many passengers as the big ones. I think the American Motors people advertise that they have a lot of room inside, and my wife had a Gremlin. It is a subcompact which could hold a lot of people. That did not seem to me to be the problem. The big problem seems to me to be the fact that the American car industry is geared to produce big cars, and consequently a big car is a better buy than a small car. I was appalled at the price I would have to pay for a lousy compact when I could get a nice Buick Le Sabre, which I ended up buying.

Mr. Yates. What is a "lousy compact"?

Mr. Long. They all look lousy to me. They look too small. It seems to me when you pay $5,000 or $6,000 for an automobile—I paid $6,200 for a Buick Le Sabre. I could pay that much, even more if I wanted to for a compact, and I couldn't see it as a decent buy. That is all. I was also misled. Of course I wanted to be misled, that is the way all of us are, by the EPA gas mileage, which is thoroughly mendacious. In that Buick of mine the EPA gas mileage, they list EPA gas mileage as 19 on the highway, somewhat less than that in the city. I get 12 miles on the highway, which incidentally doesn't surprise me too much, so I

allowed myself to be seduced, but the truth is the EPA are a bunch of damn liars.

Mr. DUNCAN. What has that got to do with your car?

Mr. LONG. This led me or helped me to buy the bigger car. They were able to sooth my conscience with this kind of stuff. I think you have got to get people to buy the smaller cars. We have got to almost prohibit the big cars to be built or I think the President's idea of putting a big tax on them to make you pay so much that an awful lot of people will back away from them.

Mr. MURTHA. But you would get a rebate in buying a Le Sabre. You would get a $90 rebate.

Mr. YATES. No; it is an 8-cylinder gas guzzler.

Mr. MURTHA. But according to EPA he would get a $90 rebate. There was an article in the paper today.

Mr. YATES. That is a General Motors rebate. That isn't a rebate in the President's plan.

Mr. MURTHA. No, no.

Mr. LONG. I got a lot more than that from General Motors.

Mr. GREER. The Wall Street Journal carried an article indicating that there would be a $90 rebate.

Mr. MURTHA. On the Buick Le Sabre.

Mr. YATES. Why?

Mr. MURTHA. Because it is considered a car that has economy above whatever the standards are—15 miles per gallon.

Mr. LONG. It is a damn lie. I don't believe you could get 15 miles on any Le Sabre ever built.

Mr. YATES. As soon as Dr. Long and Mr. Murtha get through, we will listen to Mr. Duncan.

INVENTIONS RECOMMENDED TO ERDA BY NBS

Mr. DUNCAN. I would like to direct your attention to these inventions that were recommended to ERDA by the National Bureau of Standards, if this is an appropriate time to start talking about them.

Mr. YATES. I think so.

Mr. DUNCAN. Because it seems to me that they cut into the problem that we are discussing, because here is this guy, Vince Carman from Portland, Oreg., who claims, and has now demonstrated not once but twice, that with his hydraulic accumulator he can double the mileage. He claims he can take a Cadillac and give them 60 miles to the gallon.

Mr. YATES. Is this the same Vince Carman you talked about yesterday?

Mr. DUNCAN. Yes. Here I see on this list of some 27 inventions from little guys that have been submitted to you and approved by the National Bureau of Standards, a guy named Csonka who has a microcarburetor that he thinks by atomizing the gasoline will permit it to be more thoroughly burned. I just looked at a project here of a guy who has a different type of sparkplug that introduces two sparks instead of one, and I know that there are some experiments with double sparkplugs putting two so you get better combustion. These little inventions don't fall into the class of $500 million that we need for these fluid bed operations or these magnetohydrodynamics or whatever it was you were talking about.

I would like you to tell us, if you will, what you are doing about these. Is this in your field, sir?

Dr. MANNELLA. Yes, it is.

Mr. YATES. These for the record refer to what?

Mr. DUNCAN. A list that I guess was submitted by ERDA of inventions recommended to ERDA by the National Bureau of Standards as of March 1, 1977.

Dr. MANNELLA. First, I cannot resist telling Mr. Long, when he trades that Le Sabre in in 1987, if it is new and has a turbine, he will get 27 miles to the gallon.

Mr. YATES. In 1987.

Dr. MANNELLA. Yes.

Mr. YATES. What is he going to do in 1977?

Dr. MANNELLA. He is going to drive the Le Sabre he just bought, I guess.

Mr. YATES. What should he have done?

Dr. MANNELLA. Obviously buy a smaller car.

Mr. YATES. You mean a lousy compact, to use his phrase.

Dr. MANNELLA. I was just repeating what he said.

Mr. YATES. Mr. Duncan is serious, and I am serious, too, about this question, particularly with respect to his friend Vince from Portland, Oreg., because we have to protect the people who come from Portland, Oreg. We owe that to Mr. Duncan.

But I have been wondering, too. I drive a gas guzzler. Mr. Duncan comes along with an inventor who says, deliver me your gas guzzler and instead of drawing 10 miles to a gallon or 12 miles to gallon with your Buick, if you take the transmission out and put the accumulators on the wheels, you will be able to get 55 miles per gallon. Is that correct, Mr. Duncan?

Mr. DUNCAN. Well, he will approximately double the mileage on the same vehicle. I don't know anything about them but the National Bureau of Standards thought it was an idea worth studying and we get a report, after actually pulling it out by the teeth, out of ERDA; we get a four- or five-page document that says that is nonsense, but yet does not, on a point-by-point basis, refute what the National Bureau of Standards says.

Mr. YATES. Was it Dr. Mannella who said it was nonsense, or Mr. Brogan?

Mr. DUNCAN. I have the name of the chap. It wasn't either one.

IMPLEMENTATION OF THE ENERGY INVENTION EVALUATION PROGRAM

Dr. MANNELLA. Let me respond to this, if I may. I think that I would like to make two basic points. One of them is that as we go through the process of developing our program, of justifying it with OMB, Congress, before you gentlemen and whatnot, there is a tendency to try to zero in on very discerte, identifiable types of programs and projects that have milestones, dollar figures associated with them, cost to complete, and what have you. In this process, starting out at ERDA and coming full circle, these things get looked at, get scrutinized for deficiencies, for areas where technology is not available, and what have you, and the programs tend to be very complete programs in and of themselves. So when we get here and we say that we are undertaking a

program to develop a turbine engine for an automobile, we mean the whole turbine engine. We don't say we are going to develop the turbine engine and we are going to do everything except the seals or everything except the heat exchanger, and we are going to hold that area and wait for somebody to come in somewhere along the line with some technology that is applicable to that. If we did that I don't think we would get very far with our program.

So consequently, when you have the type of program that is made up of discrete major projects and somebody does come along with some idea it is very difficult for them to compete against the projects for funding and attention because the dollars tend to be committed to the projects to meet the goals, to meet the milestones, and to fulfill what we have told the Congress we are going to do.

Mr. DUNCAN. It becomes institutionalized; your program does.

Dr. MANNELLA. That is exactly true. The idea of retrofittable devices has been around for a long time and various studies have been made, particularly certainly as regards the automibile. The Department of Transportation made a study several years ago and canvassed every retrofittable device that had ever been talked about or claimed, and concluded on balance after they looked at all these that they either didn't perform or the ones that performed would never penetrate the market because they were too expensive, too expensive to install or something of that sort.

The yield in this area is relatively low, and we have 4,000 inventions submitted to the National Bureau of Standards during the course of the past 2 years, and out of this we come out with a handful that pass technical muster.

The Bureau of Standards only looks at these things from the standpoint of what they see on paper—does it violate any known laws of physics or engineering? Is it technically feasible?

Mr. DUNCAN. I have no argument with that, and the ones I worry about are the 22 that they submitted to you.

Dr. MANNELLA. The ones that come in, as I say, have to compete with the projects for resources and it took us a while to realize what was going on. It took us a while to realize that the way things were developing these projects which were never really developed and frequently did not have the data to compete with other elements of projects, or what we see in unsolicited proposals, were at a disadvantage. As a result of this Mr. Fri, our Acting Administrator, did essentially create a fund in 1977 where he set aside certain moneys to be reserved for those inventions which, having passed the technical scrutiny of the Bureau of Standards, having been reviewed by the program people as being not duplicative, or overlapping with any existing work, could be funded to the extent that some prototypes could be built, some hardware could be developed, and they could compete on even terms with the more general type of proposal, with the more general type of project that we undertake.

CARBURETOR INVENTION

What we are doing in the case of the carburetor you mentioned, the individual came in and asked for a substantial amount of money to essentially go into production, and we just felt that we could not

commit those kinds of appropriated funds for an item that we had never seen in a hardware stage, so we are going back to him with a counteroffer proposing to fund him to the extent that some of these devices can actually be made, tested, some assessment can be made as to how crucial the orifice has to be, and whether or not it would be practical to use these in the real world, and how critical the dimensions are, and what the erosion of the fuel over the period of use might destroy the particular unique effect of the carburetor and do that kind of evaluation before we would commit ourselves sooner.

TRANSMISSION INVENTION

In the case of the transmission, we were not actually able to provide the inventor with funds, but we have contacted him, and he has gotten private funds, I believe, and we have made arrangements with the Jet Propulsion Laboratory to test that transmission and to generate enough data that some evaluation could be made to see whether or not it could compete with the other types of projects that we have ongoing.

Mr. DUNCAN. Are you going to finance that experiment with the Jet Propulsion Laboratory?

Dr. MANNELLA. The testing, yes.

BASIS FOR ERDA DECISION ON TRANSMISSION INVENTION

Mr. YATES. The question in my mind though is why you would send a letter like that out telling him his invention wasn't any good.

Dr. MANNELLA. I don't think we said that, Mr. Chairman.

Mr. DUNCAN. Yes, you did. You said it would only produce 3 percent fuel savings.

Dr. MANNELLA. I don't think that that is quite the same thing. We do reserve the right to differ with the inventor on the interpretation.

Mr. DUNCAN. This is the National Bureau of Standards, and I would concede your right to differ with them. The only thing is there wasn't any point-by-point rebuttal after the Bureau of Standards analysis which I thought was the least you ought to do. I am accepting what you are saying here today as a statement that last year and the previous years this program was shortchanged, and that you have now adopted a different policy where you have actually pigeonholed some funds that will be available in this category.

Dr. MANNELLA. Yes.

Mr. DUNCAN. The reason I am glad to put that on the record is because I was going to suggest that this committee ought to make such an allocation as we make the appropriation because these are comparatively small sums that you are talking about, aren't they?

Dr. MANNELLA. No, sir.

Mr. DUNCAN. Well, they can be.

Dr. MANNELLA. They can be, but they are not necessarily. In the carburetor the request goes for $1.5 million.

Mr. DUNCAN. That is an awful lot less than the 500 million bucks we were talking about in some of these other proposals and in the money you are talking about with Stirling.

Dr. MANNELLA. It is only a piece of paper at this stage of the game.

Mr. DUNCAN. But what I saying is that it wouldn't take very much money on any one of them to move them beyond that paper stage.

Dr. MANNELLA. I would agree, and if we had some process where we could unfailingly select those that will be successful we would be happy to do it.

Mr. MCKAY. Would the gentleman yield?

Mr. DUNCAN. If I can just say one more thing, unfailingly, I don't know how. You haven't asserted with respect to any one of these programs that the work you are doing is unfailing. If it were you wouldn't have to build pilot plants and demonstration plants before you went into commercial production. I don't think what we are talking about is being able to have prescient intuition.

AUTOMOTIVE GAS MILEAGE GOALS

Mr. LONG. I would like to get to a question which I was getting ready to propose after my preamble. I am trying to understand the President's energy saving and conservation program. I am trying to get some feeling for what it means in terms of gas mileage in automobiles. What kind of a gas mileage car is the administration trying to promote? Is it trying to promote one in which you get 40 miles to a gallon, one on which you get 30, 20, 12 like my Le Sabre, or 5, like some of the Cadillacs and so on? What are we aiming at?

Now, if this is true, the stuff is coming out that they are even proposing that a Buick Le Sabre could be qualified for a rebate, then I would say you are on the wrong track.

I don't care what your EPA gas mileage says, because you haven't found anybody yet who thinks the EPA gas mileages are on the level.

Dr. MANNELLA. Mr. Long, as I understand the situation, what the President has proposed is the following: The Energy Policy and Conservation Act of 1975 established minimum fuel economy standards for cars in the United States by fleet average, and as I recall the specifics of that act, there is a progression of numbers, minimum fuel economy standards, after 1980 which the industry must meet on a sales weighted average, culminating in 1985 with a fleetweighted number anywhere from 26 to 27.5 miles per gallon. And that number was to be set by, I believe, the Secretary of Transportation.

What the President is saying is let's set it at 27.5 miles per gallon now.

Mr. LONG. Now, is that 27.5 miles a gallon that you and I would get—the real car on the highway—or is this gotten by running some car under idealized conditions? Because when you talk to car dealers they all laugh at us as if you are totally naive if you expect to get these EPA mileages that are listed on the cars and in the little booklets that they hand out.

They point out how it is done. The darn cars are put on a lift somewhere and run for so many hours, and it is not really a genuine test of mileage.

Is that what we are going to get?

Dr. MANNELLA. Let me try to defend my sister agency briefly here. Any test that you have has to be standardized. The difference with the mileage test is people know the mileage you are getting. When you buy an air-conditioner that is rated at 5,000 Btu's, nobody really bothers to check whether it delivers 5,000 Btu's in the particular location you have put it.

There are a lot of variables in driving. The driver is probably the biggest variable, frankly, but there are other factors, the wind, et cetera, and so they do test these vehicles in a controlled temperature dynamometer lab.

The reason is as follows: They are tested in those labs for emission standards to begin with. When the notion of minimum fuel economy standards came along it turned out that you could compute the mileage on a simulated city-highway system by taking some of the basic data from the emission standards and it was deemed that the most efficient and least costly way to arrive at these base line figures, which are just there for comparative purposes, was through the emissions testing.

When you see a sticker that says this car gets 19 miles combined cycle, it doesn't mean that you or anyone else——

Mr. LONG. Excuse me, not combined; 19 miles on the highway. But it gets 12 on the highway, and I never expected any auto dealer to tell me anything different from what we got. My previous Buick got 13, and this is a little heavier, so it is about what you would expect. I love the car. It is a great car. But if that is the kind of car you are trying to promote for mileage economy, then you are selling a bill of goods to the American people.

Dr. MANNELLA. We are not trying to promote any kind of car.

Mr. LONG. I mean the administration is trying to promote that level.

Mr. YATES. I don't think they are.

Mr. LONG. Don't you think we have a right to get some sort of feeling as to what kind of a car they are actually trying to promote in this effort to get fuel economy?

Dr. MANNELLA. Sir, we are trying to develop a gasoline engine which will be 50 to 60 percent more efficient than the kind of internal combustion engine we have today, and put in any vehicle of any size or weight it is going to consume one-third less gasoline per mile that it is driven than with the conventional engine.

Mr. YATES. May I interrupt there? If that is true why don't we use the European engines that save so much more money?

Dr. MANNELLA. Those are small four cyclinder engines. They are perfectly suitable for the 2,000-pound vehicle.

Mr. YATES. Let me ask you another question to supplement what Dr. Long said, and Mr. McKay is the one who made the point. He said if you put a kitty-car, or something slightly more than a kitty-car in weight—I guess the Honda is the lightest car that is being sold these days, isn't it?

Dr. MANNELLA. I am not sure whether it is still the lightest.

Mr. YATES. It is kind of a shell on wheels, isn't it, with an engine?

Dr. MANNELLA. The Honda has grown quite a bit in the last several years.

Mr. YATES. What is the lightest car you know?

Dr. MANNELLA. Subaru was for a while.

Mr. YATES. Let's take the lightest car you have. The Honda according to EPA averages gets about 52 miles on the highway. As I recall the Mazda Miser, or one of them, gets 52 miles on the highway.

Now, if that car were part of an American fleet that would be added to the other cars in the fleet, wouldn't that permit the gas guzzler to be sold?

Dr. MANNELLA. Yes, sir, that is correct.

Mr. YATES. Because of the average, so that Dr. Long could continue to buy his Le Sabre provided that the Buick Co. or General Motors—I don't know what the requirement is—the Buick Co. or General Motors were to create a smaller car equivalent to the one that got 52 miles.

Dr. MANNELLA. Or if they sell enough Chevettes then you can buy any size vehicle you want.

Mr. YATES. That is the theory of the legislation that Congress approved.

Dr. MANNELLA. That is correct.

STRATEGY FOR TRANSPORTATION ENERGY CONSERVATION

Mr. YATES. Now, if you will defer for just a minute, I hate to leave this interesting topic, but we have to get the record in shape a little bit too, and before the diversion onto the car I was trying to find out how your agency was created and organized in order to attack the conservation problem. We were in industry and all of a sudden we moved to the authomible and we never got out of the automobile.

Dr. MANNELLA. I chose to respond of the three end use areas with transportation first because the point I was going to make is that you can really zero in on the automobile, which means that if you understand what the several companies are doing you really understand what is going on in the entire industry. So in transportation the problem of being cognizant and aware of all the initiatives that are going on from an energy technology standpoint is fairly simple.

Mr. YATES. How simple is it when you have all forms of transportation to contend with? You not only have your small car. You have the buses. You have the question of trains. You have the question of trucks. You have planes and so forth, haven't you?

Dr. MANNELLA. The point I am making, Mr. Chairman, is if you look at transportation energy, it is 25 percent of the total that is consumed in the United States.

Mr. YATES. That is all forms of transportation.

Dr. MANNELLA. Yes. Of that 25 percent, 75 percent is consumed by highway vehicles, and that really means——

Mr. YATES. That includes automobiles, trucks.

Dr. MANNELLA. It is automobiles and light trucks. There are very few buses and very few large trucks. So what I am saying is if you are familiar with what a few corporations are doing you have really got a pretty good handle on everything that is going on in not only the highway vehicle area but percentagewise the entire transportation field.

Mr. YATES. All right. That is one facet of it.

Dr. MANNELLA. That is one area.

Mr. YATES. Now let's take real estate.

Dr. MANNELLA. In the buildings area it gets a little more——

ORGANIZATION OF TRANSPORTATION ENERGY CONSERVATION

Mr. YATES. So what are you doing to handle it? How are you set up to handle the transportation? In your own shop what do you do?

Dr. MANNELLA. We have a transportation division which is structured in such a way that we can either through our contracts or our professional society attendance have a very good understanding of what is going on. As a matter of fact, last week here in Washington we hosted an international meeting connected with NATO on automobile propulsion systems and we really had the free world automotive community here in Washington, and by interacting with them, the papers that they presented and the private meetings, we can really find out what is going on all over the world because if you contact eight or nine automotive companies you essentially have covered the free world.

INTERACTION WITH BUILDINGS INDUSTRY

When you get into buildings, you immediately sort of divide them into two parts: commercial buildings and residences. In commercial buildings we are interacting with institutional groups like the Building Owners and Managers Association, BOMA, with the American Institute of Architects, with organizations of that sort who represent institutionally this sector of our society. In the residential area it is much more difficult. There are 47 million houses out there and we interact with HUD, which has a lot of programs one way or another related to housing, and we interact with the National Association of Home Builders; we interact with the League of Women Voters.

Mr. MCDADE. How about the VA?

Dr. MANNELLA. The Veterans' Administration also. So we interact with those institutional forces that exist and which can give us a pretty good understanding of what is going on in this area rather than to try on any continued basis to interact with thousands of individual builders that exist across the United States. We do interact with some of these individual builders. They have sought us out and talked to us about energy conservation techniques. Some of them have begun to build energy conservation into their product and to stress it and sell it and at least one of them has a very good slide show that he uses which he has coordinated with us which is very attractive.

INDUSTRIAL ENERGY CONSERVATION

Let's talk about industry, which is the most difficult area. We haven't really yet perfected the technique by which we could hope to become conversant on a continuing basis with everything that is going on in industry. We can concentrate on a number of industries because they are the most energy-intensive industries. These are metals, glass, cement, associated products, chemicals, paper. Help me out.

Mr. HARVEY. Petroleum refinery.

Dr. MANNELLA. There are about six that account for 75 percent of the total energy consumed.

Mr. YATES. What about public utilities?

Dr. MANNELLA. Public utilities are separate. We have a separate division which does not come under the purview of this committee which interacts primarily with the public utilities, the Electric Energy Systems Division.

Mr. YATES. Electric energy systems, energy storage systems.

Dr. MANNELLA. Yes.

Mr. YATES. That is a separate division.

Dr. MANNELLA. There are two divisions. Electric energy systems is one division. Storage is a separate division, but those two programs——

Mr. YATES. OK.

FOCUS OF INDUSTRIAL ENERGY CONSERVATION PROGRAM

Dr. MANNELLA. So we concentrate on those six industries which represent the bulk of the energy that is consumed in the industrial sector.

Mr. YATES. What percentage would you say those represent?

Dr. MANNELLA. Seventy-five percent of the total energy consumed in the industrial sector.

Mr. YATES. Automobiles, light trucks, in transportation. You have 75 percent represented by those six industries in the industrial complex. Right?

Dr. MANNELLA. No. I am sorry. I didn't follow that. Automobiles and light trucks are 75 percent of the 25 percent of the total that transportation takes.

Mr. YATES. Sorry.

Dr. MANNELLA. And we are still finding our way in the industrial area frankly, still developing relationships and trying to see whether or not workshops, seminars, working with industrial groups, trade associations, and what-not is the best way to get this information. It is very difficult because this is a very competitive field and the information is proprietary. They are very reluctant to put this information into the public domain, which we fully sympathize with.

PARTICIPATION OF SMALL BUSINESS AND INDIVIDUALS

Mr. MCKAY. What strikes me is you go on and say if we get through six groups here we have pretty well got the industry tied up, and all the way along you sorted out four or five. It appears we get to a monopolistic circumstance and they are in fact writing the policy or we are writing the policy around them.

Mr. YATES. Back to the statement of the gentleman from Oregon, we talk about these plants and going through demonstrations and so on. It appears that the big fellows who write the broad checks and the demonstrations have the technology to meet the bureaucratic jargon, that is an acceptable grant, whereas the the little fellow isn't able to do it and yet if his proposal were written up in the same form as the one for fluid bed combustion, it might get the same consideration. That is what strikes me.

Dr. MANNELLA. It might, but I cannot say that that would categorically be true. One of the things that these more institutionalized groups offer that is very attractive to us is a higher probability of successs from the commercialization standpoint. When an organization that has within its known means the decisionmaking and the capital to put something in place, wants to do business with us, you can be reasonably sure that if the technology is successful that it will be commercialized, and our end goal is not to develop the technology but to save energy.

Mr. MCKAY. Wait a minute. You have all kinds of people out here and I will give you an example on the lease situation for oil and for

minerals. Ninety percent of the oil is found by some little rock picker out here who is looking around for either oil or copper or something else, and he comes out and he cannot develop anything, but he has found it. Then he goes to the people you are talking about and they buy it and produce it.

Now, why isn't that possible with this guy the same as it is with the guy who finds the minerals?

Dr. MANNELLA. I don't know that it isn't possible. If the gentleman's product turns out to be competitive and has suitable——

Mr. MCKAY. But you are not giving him the chance to either sell it through you to the corporations or the corporations through it.

Dr. MANNELLA. We are trying to.

Mr. MCKAY. No; you shut him off. You said, no, we are not interested, sorry.

Dr. MANNELLA. I am sorry, that is not true.

Mr. DUNCAN. Would you yield?

Mr. MCKAY. Yes.

TRANSMISSION INVENTION PROPOSAL

Mr. DUNCAN. You really did, but you have backed up. I want to be fair to you, because look at this. The Bureau of Standards wrote you a letter and said that we recommend it as being technically valid and worthy of consideration for Government support, and they back that up with a table in which they gave their estimates of fuel saving for various uses, private and other automobiles, urban miles per gallon from 10.7 to 21.4; taxi, 9½ to 19; police, 7½ to 15. The smallest saving of all of about eight categories itemized by the Bureau of Standards, not the inventor, was just about 20 percent. That is the smallest and goes up to 50 percent. ERDA responded to that not directly to the guy but in a letter to Lawton Childs——

Mr. YATES. How did it get to Lawton Childs?

Mr. DUNCAN. Because this guy had some connection down in Florida and the Floridian went to Lawton Childs. Here in November 1976 they wrote ERDA really a 1-page letter—there are four lines on the second page—in which they say:

> We regret to inform you that TEC has declined Mr. Carmen's invention on the basis that it is not cost-effective. It does not meet their standard criterion of representing a saving of at least 8 percent over existing technology with which it is competititve. They do not therefore feel that the technology would represent a sufficient impact on the Nation's economy to warrant the support of its development by ERDA.

Mr. YATES. That seems to me to be a certain conclusion with no facts to back it up, simply kissing off the Bureau of Standards' report.

Mr. LONG. To say nothing of a U.S. Senator.

Mr. DUNCAN. And at that time one demonstration. He has since done two demonstrations. You tell me he has now gone to Jet Propulsion and if it works out down there I assume it will move along. But I have two questions that I would like to ask you because it isn't just Carmen's I am curious about. Here are 27. If this is happening to him it is happening to all of them. You tell me you have now set up a fund. I would like you to tell me, now if you can, for the record if you cannot, how much is in that fund and from what line item have you taken it for these small inventions?

Mr. YATES. May I interrupt for just a minute?

You know what you are doing, Dr. Mannella. That example adds force to what Mr. McKay said. You forced this man to go to AVCO rather than your funding. You are now going to fund AVCO which is the contractor and he is going to have to make his deal with AVCO under terms that are satisfactory or really compulsory, at, I guess, the only place he could get his funding. He couldn't get his funding from you. This is what Mr. McKay is saying. He is saying that aren't you requiring the individual to go to the big institutions and make whatever deal they can with them in order to get funding from the Federal Government?

Dr. MANNELLA. Well, that is clearly not our intent. Whether that turns out to be the situation in this case——

Mr. YATES. It isn't that case.

Dr. MANNELLA. That clearly is not our intent.

Mr. LONG. Not clearly not your intent. That is, what you say is not your intent, but it is not clearly not your intent.

Dr. MANNELLA. I am sorry. To me it is clear.

Mr. DUNCAN. Let me add, Mr. Chairman, the Postal Service is ready to give you a couple of vehicles to put this system on to see if it cuts their gas consumption. Trimet, the bus system in Portland, Oreg., has a couple of buses sitting out there they would love to have this rig on and rather than send them to Jet Propulsion why can't you just find them for a few thousand dollars, wouldn't cost very darn much, convert two buses, two postal vehicles, put the things out on the street and see how they work?

Dr. MANNELLA. I don't know whether those were considered. The idea of sending them to Jet Propulsion Laboratory is to get some data in some sort of controlled type of test, which is the way things are usually done. You test it in a controlled way to get some sort of base line handle on it.

Mr. DUNCAN. The institutionalized way of doing it.

Dr. MANNELLA. It may well be.

John, would you like to take a crack at this?

Mr. YATES. I was struck by that immediately. He caught it right off the bat. He said that you are institutionalizing yourselves in each of these fields with perhaps the biggest institution.

Dr. MANNELLA. I made the point at the beginning, Mr. Chairman, that as a result of our project type of set-up and orientation these ideas do have difficulty competing.

Mr. YATES. Let's hear from the relief pitcher.

TECHNICAL MERITS OF CARMAN PROPOSAL

Mr. BROGAN. I would like to say a few words on the subject of new concepts proposed to us by individuals and small firms. Our track record in this area is quite good. As one example, a clever idea was proposed by a one-man shop in New Jersey and we have funded it into a test hardware phase for the past 2 years. We are currently testing the device at the Jet Propulsion Laboratory in Pasadena. The device attempts to achieve stratified charge combustion in a conventional internal combustion engine. It offers the potential of 10-percent better fuel economy with reduced emissions. We fund new concepts

where they appear both technically feasible and offer potential for measurable energy savings.

I would now like to say a few words with regard to the Carman device and its technical merits. We are in agreement with Mr. Carman that the system should work and that the system could produce an energy saving. We never said that it wouldn't work or that it wouldn't produce energy savings. Our point has been that the potential energy savings are highly dependent on the driving cycle. The manner in which he conducted his test did show up a very peculiar driving cycle. It is claimed to have produced 50-percent energy savings. If that is correct we should be able to verify it when we test it. That is what we proposed to Mr. Carman, that is, test the invention in a vehicle and publish the results.

Mr. DUNCAN. It was peculiar. He drove around the city of Portland and around the city of Orlando. I suppose that is peculiar, but that is the way most of us drive.

Mr. BROGAN. No; the test data was stop, start, stop, start, plenty of stop, because then——

Mr. DUNCAN. Like most city driving.

Mr. BROGAN. No; on the contrary most city driving is like the EPA Federal driving cycle——

Mr. DUNCAN. Go ahead.

Mr. BROGAN. The cycle used by Mr. Carman is unique to the U.S. Post Office Department and there is the application where we believe it may well have merit. The point is that there are some 100,000 Post Office Jeeps out of 110 million cars on the road. The invention may well have merit but not for every car on the road and that is where we differ with Mr. Carman.

Mr. DUNCAN. I would be glad to see the rest of the test but in every metropolitan community between 7 and 9 o'clock in the morning and between 3:30 and 6 o'clock at night you have cars on road after road sitting there idling away hundreds of millions of gallons of gas and if they had this equipment on it they wouldn't be doing that.

Mr. BROGAN. We mentioned in our original response to this that in terms of cost-effectiveness with gasoline at 50 cents a gallon and $600 for installed cost—we can't see it coming in any cheaper—to install this over and above the existing transmission, we don't understand how that would be cost-effective, but possibly for the Post Office vehicle it might.

PROPOSED TO CONVERT THERMAL ENERGY INTO ELECTRICAL ENERGY

Mr. DUNCAN. I don't want to pursue this one any more. I would like to get general in this whole subject and here are 22 of them and all of them as far as I can tell are probably being handled the same way. Here was a hearing last June in front of a Subcommittee on Government Operations with respect to an invention that is listed here by Joseph Yater, which is the power conversion of thermal energy into electrical energy through voltage fluctuations, and in June of last year Dr. Robert Hirsch said they were going to have a report within 30 days from Dr. Kane as to what recommendations they were going to make with respect to Mr. Yater's invention.

Could anybody tell me what has happened to Mr. Yater's invention?

Mr. GREER. We have Dr. Kane here, Mr. Duncan.

Mr. DUNCAN. I do not know Yater from Adam Fox. I want to know what has happened to this program.

Mr. GREER. Dr. Kane is head of our physical research program.

Dr. KANE. Not only are we funding Mr. Yater, but I think we have treated him in a manner that really is contrary to what you say: That we have shoved these inventors into the maws of the big, graspy institutions. Mr. Yater is a typical small inventor. He has virtually no resources except his own mind and imagination. He came to us through the Bureau of Standards route and we got his invention last June. It was submitted with the approval of the Bureau of Standards, who also had sent it on to the MIT Inventions Evaluation Institute.

They have a process up at the Massachusetts Institute of Technology for evaluating inventions and Mr. Yater's invention had been screened by them. I will not read you the full report on it. I would say it was kind of a mixed report, but nevertheless there was nothing in his invention that was against the law of nature.

In other words, it looks like it had a chance, so I want to characterize this right off as a high risk but, nevertheless, potentially a quite high payoff sort of thing, and then it becomes a question of judgment. If it is extremely risky you say no, but if it is risky but with a high payoff you say let's try.

That is of course the way we have proceeded with Mr. Yater. He spent last summer trying to define his program. In other words, here is a man, as I say, with no resources. He cannot get his ideas to the state that a big corporation could because he has no resources to do it with, so last summer he defined his desires, his research, and we funded him this last fall. It took us a couple of months after he finally learned how to write a proposal to us to come to an agreement. These things have to be done exactly, not just because we are bureaucratically slow, but to protect him.

He wanted proprietary rights to his invention so we want to make sure he comes into the organization keeping his proprietary rights. I have the chronology here. We funded him about November. We gave him a $40,000 grant, not truly a grant—it was a contract—and he was supposed to use this to come back and tell us in more precise terms what he wanted to do since in this case it is a sole source contract and you have to be very careful to have the proposer outline precisely what he is going to do.

That is the status right now. We gave him the option last summer of joining in with one of our national laboratories if he wished to or going his own way and he chose on his own volition to go his own way. In other words, he founded his own small company. The current status is that he has missed his deadline. He was going to come in I think March, the end of March, with a plan which essentially would be a request for further funds, and a description of what he wishes to do. He missed that. We have granted him a non-cost extension on this, and he is going to come back sometime in the future and tell us what he wants to do.

I do not have any inkling of what the outcome of this will be. I truly mean it. It is a very high-risk invention. I am not personally

tremendously sanguine it is going to work, certainly not as well as he thinks it is going to work, but he is getting a fair chance.

When he comes in with his request for the next stage he will at least have had a chance to have advanced his concept to a level where it is able to compete.

Mr. DUNCAN. Thank you very much.

Would you insert in the record the disposition and the status of each of these other recommendations from the National Bureau of Standards and would you also tell us how much is in this fund and from what line item you propose to take it and give us that information before the markup?

Mr. GREER. We will be glad to.

[The information follows:]

ENERGY RELATED INVENTIONS PROGRAM

Attachment A outlines the current status of the 27 energy-related inventions recommended by the National Bureau of Standards (NBS) to ERDA as of April 27, 1977.

Estimated funding requirements for FY 1977 are $1,060,000 and $1,590,000 in FY 1978. An analysis of 24 NBS recommendations in ERDA plus the 35 in the second-stage evaluation phase at NBS as of the end of March, revealed the following breakdown by program office:

Program	Number	% of Total
Conservation	44	74.6
Solar/Geothermal	10	17.0
Fossil	5	8.4
	59	100.0

On this basis, the proportionate share of the total requirement for each program office was calculated as follows:

Program	FY 1977	FY 1978
AC	790,000	1,185,000
ASGA	180,000	270,000
AFE	90,000	135,000
	1,060,000	1,590,000

-A-

April 27, 1977

Inventions Recommended to ERDA by NBS; Recap, by category:

Designation and Category	Number in Category
I Recommendation Accepted: Active	
A. Arrangements Have Been Made For Further Testing -----	2
B. Business Management Assistance Being Arranged -------	1
C. Funding Mechanism Being Determined ----------	7
II Recommendation Accepted: Completed	
A. Program Office Has Assumed Responsibility ----------	1
B. Business Management Assistance Was Provided ---------	1
C. Further Testing Indicated No Additional Support Warranted ----------	0
III Recommendation Rejected ----------	4
IV Recommendation Under Evaluation In ERDA Technology Offices ----------	11
Total ----------	27

Changes in Category from the Last, April 12, Report:

Invention Number	Previous Category	Present Category
5	Being Considered (IV)	Rejected (III)
9	Awaiting further information	Being Considered (IV)
12	Being Considered (IV)	Accepted (IC)
24	Being Considered (IV)	Accepted (IC)
26	Not yet received	Being Considered (IV)
27	Not yet received	Being Considered (IV)

ERDA ENERGY-RELATED INVENTIONS PROGRAM Fiscal Year 1978	(1) Amount of Support Probable Range	(2) Assumed Average	Source of Funds	(4) Estimated % of NBS Recommendations*	(5) Estimated Number of Inventions	(6) Total Funds Requirement (2) X (5)
Category						
I. Concept requires further R&D	$ 5,000 -	$20,000	Inventions Program Fund	25%	15	300,000
II. Concept requires further testing, prototype development or demonstration						
A. Cost under $50,000	$ 5,000 - $50,000	$30,000	Inventions Program Fund	30%	18	540,000
B. Cost over $50,000	-	$50,000	Inventions Program Fund for first $50,000; AC, ASGA, AFE funds for excess	15%	9	450,000
III Concept is attractive upon initial review and program office wishes to pursue as a part of its overall program.	-	$50,000	Inventions Program Fund for first $50,000; AC, ASGA, AFE funds for excess	5%	3	150,000
IV. Concept has been fully developed but there is a need to assist the inventor with business management advice in order to prepare him to bring his product to market	$ 5,000 $25,000	$10,000	Inventions Program Fund	25%	15	150,000
TOTALS				100%	60	$1,590,000

*Extrapolated from NBS analysis of 95 inventions currently in second stage evaluation

2/8/77

ERDA ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
INVENTIONS PROGRAM
Fiscal Year 1977
(February - October)

Category	(1) Amount of Support Probable Range	(2) Assumed Average	(3) Source of Funds	(4) Estimated % of NBS Recommendations*	(5) Estimated Number of Inventions	(6) Total Funding Requirement (2) X (5)
I. Concept requires further R&D	$ 5,000 - 50,000	$20,000	Inventions Program Fund	25%	10	200,000
II. Concept requires further testing, prototype development or demonstration						
A. Cost under $50,000	$ 5,000 - $50,000	$30,000	Inventions Program Fund	30%	12	360,000
B. Cost over $50,000	-	$50,000	Inventions Program Fund for first $50,000; AC, ASGA, AFE funds for excess	15%	6	300,000
III Concept is attractive upon initial review and program office wishes to pursue as a part of its overall program.	-	$50,000	Inventions Program Fund for first $50,000; AC, ASGA, AFE funds for excess	5%	2	100,000
IV. Concept has been fully developed but there is a need to assist the inventor with business management advice in order to prepare him to bring his product to market	$ 5,000 $25,000	$10,000	Inventions Program Fund	25%	10	100,000
TOTALS				100%	40	$1,060,000

*Based on NBS analysis of 95 inventions currently in second stage evaluation

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Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 1 OERI nbr: 000019 "Demand Metering System for Electric Energy" #3,633,343. Dr. Stephen Feldman, V.P., Environmentrics, Inc. 5/23/75. Inventor and contact: Murray Lowenthal. The invention provides a means whereby a consumer's electric meter can be adjusted by the electric company to run at faster rates at times of greater loads upon the utility system -- load leveling.	R.K. Sutz	BCS*	Nov.26, 1975	March 17, 1976	April 2, 1976	Category: III Does not respond to present ERDA R&D program needs, which are of an R&D nature. The barriers to the transfer of this invention into the private sector are primarily of a sociological nature, over which ERDA has no authorized purview, therefore, rejected.
INR nbr: 2 OERI nbr: 000010 "Fuel Miser" Rita Paleschuck, Pres., Lawrence Kleinberg, Sen. Eng. Flair Mfg. Corp., 7/14/75. The device is an attachment which can be used to retrofit a room thermostat with a synchronous motor-driven clock timer and an auxiliary heating element to enable it to have a temperature set-back cycle.	R.K. Sutz	BCS Mel Chiogioji	Nov 28 1975	March 17 1976	April 21 1976	Category: IIB "Market inelasticity" was adjudged the barrier to its commercialization. A generic brochure was written and published on the "need for automatic temperature setback." Extensive distribution is underway through ERDA's Office of Public Affair's "supermarket handout" program and General Services Administration's Consumer Information Center.
INR nbr: 3 OERI nbr: 000003 "Hydrogen Generation from Producer Gas by Oxidation-Reduction of Tin," Donald C. Erickson, Energy Concepts Co., Patent applied for. 5/7/75. A new approach to the generation of tonnage hydrogen from carbonaceous fuels. Two reactions. steam with tin, whereby hydrogen is produced, and the reduction of the tin oxide produced in the first reaction back to tin.	R. K. Sutz	MER* Kermit Woodcock	May 21 1976	June 7, 1976	Nov 9 1976	Category: III Rejected, because ERDA was unable to demonstrate a clear indication of value to their programs.

*BCS - Conservation's Division of Buildings and Community Systems

* MER - Fossil Energy's Division of Materials and Exploratory Research

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 4 OERI nbr: 000230 "Power Conversion of Energy Fluctuations," Mr. Joseph Yater, 9/18/75, patent applied for. A solid state device is claimed that can transfer thermal energy into usable electrical power with high efficiency, by cascading large numbers of such circuits. *ASGA-R - ASGA's Division of Physical Research	R.K. Sutz	ASGA-R* Clarence Richardson	June4,76	June 7, 1976	July 9 1976	Category: IIA Accepted; a $40,400 contract has been granted for initial development work.
INR nbr: 5 OERI nbr: 000038 "Diesel Engine Conversion System for Gasoline Engines," Geo. C. Austin, Jr., inventor, Austin Tool Co., no patent action. The system is proposed for converting a standard gasoline auto engine into diesel engine. *TEC - Conservation's Transportation Energy Conservation Division **In which TEC reaffirms their August 25, 1976, decision.	R. K. Sutz	TEC* H. Starr	Aug 17 1976	Aug 17 1976	Apr. 6 1977**	Category: III Rejected, because in TEC's opinion the development would not achieve sufficient market penetration to justify ERDA support.
INR nbr: 6 OERI nbr: 000225 "Micro-Carburetor," John J. and Albert R. Csonka, inventors; patent applied for. FERRO Technical Company. A new kind of carburetor which is claimed to be fuel-saving and pollution-reducing.	G.K. Ellis	TEC H. Starr	Aug 20 1976	Aug 23 1976	April 6 1977	Category: IC Accepted; Processing for procurement action.

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 7 OERI nbr: 000387 "Hydraulically Powered Waste Disposal Device," Mr. Donald J. Verley c/o Piranha Products Company; Patent no. 3,700,176. The device is to replace conventional food waste disposal units which are powered by electric motors.	R.K. Suto	BCS Kurt Riege'	Aug 30 1976	Sept 13 1976	Sept 27 1976	Category: III Rejected; the potential energy-savings of the device would be minimal.
INR nbr: 8 OERI nbr: 000423 "Inertial Storage Transmission," Vincent E. Carmen, President, Global Scientific Consultants, Inc., Invention #3,903,696. The device is a system for improving the efficiency and reducing the fuel consumption of a motor vehicle, utilizing a regenerative hydraulic system to store the kinetic energy from deceleration for use in accelerating the vehicle.	G.K. Ellis	TEC - D.D. Weidhuner	Sept 3 1976	Sept 9 1976	April 6, 1977	Category: IA The Jet Propulsion Laboratory has been assigned to conduct tests of the invention and objectively evaluate the results. Mr. Carmen was informed by letter of this arrangement and was asked in writing and verbally to cooperate in this venture. The test arrangement is to be reviewed by the DOT/UMTA and Post Office Department. To date, Mr. Carmen has not kept the appointments made by JPL scientists to jointly define the testing and schedule. Development of a test plan hinges on Mr. Carmen's cooperation.
INR nbr: 9 OERI nbr: 000151 "Heat/Electric Power Conversion via Charged Aerosols," Mr. Alvin Marks of Marks Polarized Corporation. 8 patents. This device is to convert thermal energy to electric energy without the use of moving parts.	G.K. Ellis	Being determined	Sept 15 1976*	April 25 1977	----	Category: IV *After receipt of the recommendation from NBS, it was referred back for information about 5 completed Navy contracts of subject relevance totaling $750M. The information was received on April 2. The recommendation is now under evaluation in various ERDA program offices where it may have a potential fit. A meeting has been scheduled on April 29 between the inventor and ERDA personnel, at inventor's request, to present his material.

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 10 OERI nbr: 000421 "Scrap Metal Preheating Method and Apparatus," Mr. Harrison R. Woolworth, inventor. The device provides a means of extracting waste heat from hot ingots and billets and utilizing this waste heat to preheat scrap steel prior to placing it in an electric arc furnace. *INDUS - Conservation's Division of Industrial Energy Conservation	E. L. Sillcox	INDUS*- R. Sheneman	Oct 4 1976	Oct 19 1976	Oct 26 1976	Category IA Recommendation accepted for testing. From discussion at the Soule' steel plant, the invention appears valuable only in those plants, like Soule, where the procedure for cooling ingots is inherently inefficient. INDUS has sponsored a survey by A.D. Little of steel plants in the U.S. to determine how typical and widespread is the inefficient procedure which could cause need for this invention.
INR nbr: 11 OERI nbr: 000233 "Solar Collector," Ronald H. Smith, Pres. Solergy, Inc. This is a composite extruded aluminum section -- incorporating a cylindrical absorption tube that carries the working fluid. The collector surface is in the form of an Archimedes Spiral and a parabolic curve to maximize the collection angle and eliminate the need to reposition the collector. *ASGA's Division of Solar Energy	G.K. Ellis	SOLAR*- S. Sargent	Oct 4 1976	Oct 4 1976	April 26 1977	Category: IV Invention falls within area of a competitive solicitation. Solergy, Inc. has responded to the solicitation and its proposal is being considered. No further action will be taken until the outcome is known.
INR nbr: 12 OERI nbr: 000448 "High Frequency Energy Saving Device" Frank A. Summa, Electrides Corp., patent applied for. This invention consists of a high-frequency generator, to excite one of several fluorescent lights, replacing the normal ballast transformer, and allowing the system to operate at a substantially higher efficiency.	E.L. Sillcox	BCS Kurt Riegel	Oct 4 1976	Oct 6 1976	Apr. 20 1977	Category IC Invention falls within area of a competitive solicitation. However, methods of providing testing and validation are being explored.

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 13 OERI nbr: 000053 "Anti Pollution System," R. K. Bose, Patent #3,861,142. This device utilizes a high speed turbine to refine exhaust gases and recirculates the unburned portions of that gas to the engine.	E.L. Silcox	T&C M. Starr	Oct 4 1976	Oct 19 1976	March 4 1977	Category: IB T&C rejected this for program support because the energy savings did not meet their threshold criteria. T&C referred it to INR for business management assistance, which is under consideration.
INR nbr: 14 OERI nbr: 000146 "Aerodynamic Lift Translator," D. J. Schneider. Patent applied for. This device is a wind-activated power generating system intended to provide large power outputs in regions where the prevailing wind direction does not vary appreciably during the year. *informally notified	G.K. Ellis	SOLAR - L.V. Divone	Oct 5 1976	Oct 7 1976	April 26 1976*	Category: IC Recommendation accepted; funding mechanism being determined; A proposal has been requested from the inventor.
INR nbr: 15 OERI nbr: 000393 "Estacron," Dante A. Raponi, inventor. Pat pending. "Estacron" consists of an aggregate of Portland cement, fly ash, stack dust, and polyethelene. It has significant potential as a light-weight and energy-conservative construction material. Prior to this time the invention was being considered for venture capital support by Boeing Corp.	R.K. Sutz G.K. Ellis	INDUS - J. Collins	Oct 6 1976	March 1 1977*	--	Category: IV Inventor has been introduced to Gov't purchasing organizations; will be introduced to venture capital sources; invention is currently under review by AC-INDUS for consideration for ERDA funding support.

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff from responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 16 OERI nbr: 000436 "Method and Apparatus for Vacuum Drying of Commodities," John Bruce. This invention describes a new method of drying commodities, primarily applicable to such grains as corn, rice, and soybeans, by alternately exposing the commodities to dry heated air and to a vacuum.	G.K. Ellis	INDUS S.J. Clark	Dec 2 1976	Dec 9 1976	March 7 1977	Category: IC Recommendation accepted; proposal requested from the inventor.
INR nbr: 17 OERI nbr: 000619 "Osmotic-Hydro Power Generation," David W. Doyle of InterTechnology Corp. 1/19/76. Patent applied for. The invention discusses the use of reverse osmosis to produce high pressure liquid that can subsequently be passed through a hydraulic turbine to produce electric power.	G.K. Ellis	ASGA-R M.P. McGee	Jan 17 1977	Jan 18 1977	April 8 1977	Category: IC Recommendation accepted; funding mechanism being determined. A proposal has been requested from the inventor.
INR nbr: 18 OERI nbr: 000177 "The Conservation of Electrical Power Through the Control of the Analysis of Low Carbon Aluminum Steels Using Oxygen Sensors and an Iron-Aluminum Alloy," Dr. G. R. Fitterer of Fitterer Engineering Assoc., Inc., 7/23/75. Several patents. The production of "killed" steel is intended to be controlled by the use of Fe-Al alloys instead of Al and by the use of oxygen probes to control the amounts of Al or O_2 in the melt. *informally notified	E.L. Silcox	INDUS - R. Shoneman	Feb 2 1977	Feb 2 1977	Apr. 25, 1977*	Category: IC Recommendation accepted; funding mechanism being determined. A proposal has been requested from the inventor in conjunction with a steel company, since the cooperation of a steel company will be necessary in order to test the invention. A proposal has been received from the inventor, but not yet from the steel company.

Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff [illegible] Responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 19 OERI nbr: 000205 "Phenol Methalol Urea Foam Rigid Board Insulation," Walter Hasselmann, Jr., of C.F. Chemical Co., Inc. This invention is a urea-formaldehyde phenol methalol modified foam insulating board material. Properties are similar to others on the market except for its fire retardancy and the low toxicity of its combustion products.	D. Mello	BCS - Eldon Ehlers	Feb 8 1977	Feb 10 1977	--	Category: IV The invention is being evaluated by the Brookhaven National Laboratory technical managers.
INR nbr: 20 OERI nbr: 000339 "Thermal Shade," Thomas P. Hopper, 3/22/76. Patent applied for. The device is a multi-layer window shade to be fitted to conventional windows and to retract into a small space -- uses reflective surface coatings and with dead air spaces between the layers to reduce heat transfer.	D. Mello	BCS Kurt Riegel	March 2 1977	March 9 1977	---	Category: IV Recommendation under evaluation in ERDA technology offices.
INR nbr: 21 OERI nbr: 000613 "Waste Oil Utilization System," Mr. Robert S. Norris of R.S. Norris & Associates, 8/25/75. Two patents. This invention would utilize existing emulsification machinery to add a mixture of used lubricating oil and water to fuel oil used in large power plant boilers. Key point is the use of existing additives in fuel oil to prevent boiler tube deposits.	E.L. Silcox	INDUS - J Collins	March 2 1977	March 9 1977	--	Category: IV Recommendation under evaluation in ERDA technology offices.

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Date: April 27, 1977

INVENTIONS RECOMMENDED FOR ERDA CONSIDERATION BY NBS' OERI - A BRIEF STATUS REPORT

Invention data: INR nbr, OERI nbr, title, patent nbr if any, inventor's name and affiliation, and description of the invention	INR/ERIP Coordinator	ERDA Program & the staff person responsible	Dates of INR Handling: Rec'd from NBS	Referred to ERDA Program	Rec'd from Program	Program Recommendation/Comments
INR nbr: 22 OERI nbr: 000537 "Fuel Burner Attachment," Herbert G. Lehmann, 12/22/75. No patent. Device to reduce oil consumption by introducing air to oil stream of the burner.	D. Mello	BCS Kurt Riegel	March 2 1977	March 9 1977	-- ---	Category: IV Recommendation under evaluation at Brookhaven National Laboratory, which handles heating equipment.
INR nbr: 23 OERI nbr: 000951 "MicroGas Dispersons," Inventors: Shaler, McLean, Sebba of Int'l NGD Co. Patent #3,900,420. Device consists of a motor, pumps, bubble machine, and valves, uses #2 fuel oil, compressed air, surfactant, to maintain bubbles. Resulting mixture burns like natural gas, which burner can use interchangably, thereby allowing industrial burners to switch fuels. Can also use small amounts of coal dust in the mixture. *CONRT - Division of Conservation Research and Technology	D. Mello	CONRT* J.W. Birkeland	Apr.11 1977	Apr.13 1977	--	Category: IV Recommendation under evaluation in ERDA technology offices.
INR nbr: 24 OERI nbr: 000819 "Can and Bottle Crushing Apparatus" Drew W. Morris, owner of Drew-it Corp. 3/2/76. Pat. applied for. The invention consists of a portable trailer-mounted device for crushing cans and bottles thereby increasing the density of the scrap, making handling more efficient. *informally notified	R.K. Sutz	BCS Donald Walter	April 1 1977	April 7 1977	Apr. 27 1977*	Category: IC Recommendation accepted; funding mechanism being determined.

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INR nbr: 25 OERI nbr: 000002 "Sulfur Removal from Producer Gas at High Temperature," Donald C. Erickson of Energy Concepts Company. No patent. The concept envisions the removal of hydrogen sulfide from a high temperature "reducing gas" stream using two scrubbing stages in series, a molten carbonate salt bath and a molten copper bath, each complete with a continuous regeneration cycle.	E.L. Silicox	MHD - Kermit Woodcock	Apr. 6 1977	Apr. 26 1977	--	Category: IV Recommendation under evaluation in ERDA technology offices.
INR nbr: 26 OERI nbr: 000782 "Compact Energy Reservoir (CER)," Seymour Jarmul. No patent. This is a device to store energy in fused salts in an insulated box at the point of use. *Conservation's Division of Energy Storage Systems	E.L. Silicox	STOR*	Apr. 12 1977	Apr. 26 1977	--	Category: IV Recommendation under evaluation in ERDA technology offices.
INR nbr: 27 OERI nbr: 001205x "Waste Heat Utilization for Commercial Cooking Equipment" to recover some of the energy in such a way as to avoid interaction with grease vapors, Robert J. Jones, inventor.	D. Mello	BCS - Kurt Riegel	Apr. 14 1977	Apr. 21 1977	--	Category: IV Recommendation under evaluation in ERDA technology offices.

Mr. GREER. Mr. Chairman, maybe I could make two points.

A couple of months ago Bob Fri came down directly on this program and put Eric Willis in charge of it. He said that we were not living up to our responsibilities as an agency, and that the program administrators have as much responsibility in this area as they do for their institutional programs. He said we are going to change the way we handle this effort so we can bring these proposals up to a competitive range, and he directed me to figure a way to pay for it.

We decided that you want the expertise of program people involved in evaluating these inventions and considering them in the context of their total program responsibilities. The ideal way to do that would be to take a little of the programs money and set it aside. The program then can get it back by putting it to work in the small invention program. So essentially what we did was tax each of the program administrators a few hundred thousand dollars and created a fund of about $1.6 million to support this program in 1978.

Mr. DUNCAN. Is Dr. Mannella blessed with this baby?

Mr. GREER. Dr. Mannella gets a lot of them because many have to do with conservation——

Mr. YATES. Incidentally, have you asked for this kind of a floating reserve in this budget?

Mr. GREER. No. We asked the program people to build this support into their own estimates. We feel that they ought to build it into their own budgets so that they can support this effort and feel responsible for it on an ongoing basis, just like they do the basic research in support of universities.

Mr. DUNCAN. The committee does not want you funding every perpetual motion man that comes down the pike but at least I think these guys ought to get a chance.

Mr. YATES. There is an interesting point here and he is under compunctions of the law. He really stretched the law a little bit by setting up this kind of conditional funding in the same way the Smithsonian did when they set aside funds which had been appropriated for a particular purpose to take care of this kind of a contingency. I mean we will overlook it but I think that we ought to be able to set it up in a way that it accords with the law now.

We agree with you. We think this is essential to take care of what might be a very worthwhile invention and not require you to send it to either Chrysler or General Motors or somebody else in order to get his funding.

Mr. GREER. I ought to distinguish between the Smithsonian and ours. Here we felt that it is part of the program responsibilities to look at these inventions and to fund those that were——

Mr. MCKAY. All you are telling us is that you require Dr. White and others as part of their research to become part of a broader thing.

Mr. GREER. That is correct.

Mr. YATES. Of course, but we had not appropriated for that.

Mr. MCKAY. Specifically except they assigned that as part of their responsibility and they are supposed to find it.

SMALL BUSINESS ADMINISTRATION INTERFACE

Mr. McDade. Do you have SBA representatives scattered throughout your agency?

Mr. Greer. We have a group of people who look after the small business set-asides in our procurement office.

Mr. McDade. No, I am not thinking of it in terms of procurement if you are going out to procure something. I know you have a set-aside program. I am thinking of it in terms of the way we have been discussing it here, the fellow who comes in who is described as not having any kind of a company but an idea.

Do you have an SBA interface there?

Mr. Greer. Yes, we do. Maybe I could introduce Dr. Eric Willis, who handles the inventions program. Bob Fri has given him responsibility for that.

Mr. Yates. Please do.

TYPES OF ENERGY INVENTION PROPOSALS

Dr. Willis. This is a very serious problem with us. Inventions, as Dr. Mannella mentioned, start off at about 4,500 that go through the hopper and have ended with 27 coming out the other end. They fall into three categories when they come out the other end. One category, which is unfortunately very rare, is the one that meets the ERDA program requirements and can be plugged in very nicely. That is such a rarity that category 1 hardly exists.

Category 2 is the type of invention that could, if it were assisted, become a proposal which ERDA might accept for fruition, or it might be assisted to become commercially applicable.

Category 3 is the type of proposal that ERDA has no business in simply because it is already a commercial proposition. It is an invention. It has gone through the mill. It comes out as a commercially applicable idea. The proper route for that is some type of commercial funding, either through the Small Business Administration or some other means. ERDA does not have direct responsibility. Lending institutions, however, are rather reluctant to take on this type of loan. They call them "Hail Mary" loans and are not too happy to invest in them.

Somewhere along the line, however, there is a need for being able to handle the small inventor who is also small business, almost invariably small business. As Dr. Kane said, he has very little business acumen. He has a poor business mind. He needs some type of shepherding into the capital market so that he can market his product.

It is a market process we are looking at, not an R. & D. one which ERDA would normally be associated with.

On the second category, I think we can be extremely helpful, either bringing an invention to fruition so that it can be planted in the ERDA process or bringing it to fruition so that it can be marketed. There is a bifurcation point.

Having had the 4,500 inventions processed through NBS—and Dr. Mannella is absolutely right, what they do is evaluate the invention to see that it doesn't violate the laws of physics or nature—they do not, however, perform any physical testing on the product. NBS looks

at the inventor's claims, and in the Carman case, which I will be happy to discuss at further length if you so wish, the inventor's claims are taken at their face value, and approved on their face value if they appear to show a savings based on some track records.

However, when the inventions are passed through to ERDA, they fall into this limbo land, where they are not quite ripe for funding by the divisions per se, and they need fine tuning on them to get the specifics honed up and do more test work. That is where we need some assistance for this. It is for this reason that the fund was set up.

Mr. YATES. That's understandable. Obviously the committee is very much interested in the field of conservation. What was it that I think Dr. Schlesinger or some other wise man said? If you can save one barrel of oil, you don't have to import two barrels of oil, so we are very much interested in conservation. We have been disappointed almost from the start in the conservation field, when it was originally set up, both in FEA and in ERDA.

I think ERDA is aware of that. We think you are moving in the right direction now, and it is a terribly complex problem. We appreciate that. I am speaking for myself and I think for some of the other members of the committee.

I am concerned about the fact that you may be crystalizing or institutionalizing, if you want to call it that, to the point where you are really protecting yourselves by setting up certain guidelines and certain formats, and so not really accomplishing your job.

If you were to ask me what the better way of doing it is, I am afraid I wouldn't be able to tell you.

Mr. MCDADE. Would you yield, Mr. Chairman?

Mr. YATES. Yes.

INTERFACE WITH SMALL BUSINESS ADMINISTRATION ON INVENTION PROPOSALS

Mr. MCDADE. It seems to me when you get through this process, the place these people should end up is very, very tight with the SBA. If a fellow with an idea and very little capital, but an idea that might fly, is looking for some kind of financial assistance, and the marketplace is going to be the test as well as the scientific aspect of it, that is what SBA does. It is not what you fellows do.

Dr. MANNELLA. That is correct.

Mr. LONG. But if they get a letter like that, after the Bureau of Standards has approved it, they are not going to get any money from SBA, right?

Mr. YATES. Do you yield to Dr. Long?

Mr. MCDADE. I am privileged to sit on the Small Business Committee that handles procurement and oversight, and we would be delighted to informally arrange any kind of meetings where you could, if you found a fellow who needed a couple of thousand dollars maybe to try it on taxis, buses or whatever it is to see if it works, to sit down and work out some kind of an arrangement that I think SBA would be happy to work it out with you.

They are in the capital business and you are not, and after you make your evaluation, I think that that is the natural place to go. We would be delighted to help you get to it.

Dr. WILLIS. That takes care of one side of it. We are still left with the side that would still need R. & D. and would normally go through the ERDA process chain.

Mr. MCDADE. Even with that, don't you get to the point where it has got to be brought to commercialization?

Dr. WILLIS. Absolutely.

Mr. MCDADE. Where do you go then? You have still got to go to SBA, or you are going to send them to Avco or some place.

Dr. WILLIS. The trouble is when the inventor comes out of NBS he is led to believe that he has received a good housekeeping seal of approval which can be parlayed someplace. It doesn't unfortunately work out that way. During the last 6 or 8 months as these inventions have come out of the NBS hopper, we have had a rather difficult learning process. We didn't know when we started what type of inventions would come out, what spectrum of activity they would embrace, and what spectrum of personalities the inventors would have. Perhaps we should have known, but we didn't.

Now we are faced with the process of brokering them around the most appropriate avenue for the fulfillment of their idea.

Dr. MANNELLA. Mr. McKay, I wonder if I might just make a comment here.

Mr. LONG. I haven't gotten a response to the point that I made a few minutes ago.

Mr. MCKAY. Clarence, I think obviously the lead research agency said to the SBA, it is not going to be a mousetrap at all let alone a better mousetrap, SBA wouldn't lend the money and neither would the banking institution.

Dr. WILLIS. You are correct.

DEALING WITH INDIVIDUAL INVENTORS

Mr. MCKAY. Something occurs to me here. You have some problems, too, as you indicated earlier.

Dr. WILLIS. Very much.

Mr. MCKAY. About the inventor who can see his fortune rising very high on the scale, and he is not willing to contract except on his own base, to 90 percent of parity and so on. As a result he is always pushing around and he goes to his Congressmen or others to try and force it.

I have been through a lot of that. It is true a lot of these people are not very good managers. There is an experience in my own State where Philo T. Farnsworth, who is accredited with the early beginnings of television, died without much of anything, but had a fantastic mind. He had things all over the pass, but he needed someone who can manage those things into fruition.

My guess is if you could get into his files someplace there is probably a whole raft of things that somebody could pick up yet that may be developed at some point.

I don't know how you do that. I suppose you send him to the Massachusetts Institute of Technology, who exploits it, and we recently just had a scandal over all those private corporations who decided, and got into advertising, that if you have got an invention come and see us, we will get it on the market now.

The success ratio of that has been what, 1 to 100, or almost zero. In fact there are a lot of scandals involved with that sort of thing. All

I did was bring up the point. You do have some problems, but on the other hand you really need to somehow tap that mental resource which is at work constantly on these things, if there is any way we can overcome them.

Go ahead.

Dr. WILLIS. Some of these people are very difficult to do business with, as a matter of fact. They are secretive.

INVENTION CONCERNING ELECTRICAL MOTORS

Mr. MCDADE. Did you do business with this fellow who is on the front page of the Post today. With a 20-percent saving on all electrical motors that FEA is supposed to have looked at.

Dr. MANNELLA. I will be happy to tell you the background of that, if you are interested in it.

Mr. MCDADE. Yes.

Dr. MANNELLA. We were made aware of Mr. Wanlass and his invention a month or 6 weeks ago by FEA, which frankly is the appropriate method. That is the way the system is supposed to work. ERDA should be looking at new technology. When somebody says, "I have developed something," and it is in the marketplace, it should be FEA's responsibility. They asked us, in view of the claims associated with that, if we would take a look at it, and we did have a member of the ERDA staff go out and talk to Mr. Wanlass, inspect his device, see it in operation, talked to people, Southern California Edison and other people who were using it.

It turns out that the device indeed performs pretty much as advertised, and it seems to be a situation where this individual had certain skills and talents and when he saw the energy crisis coming, he put them to work. He developed the product. He sold it to Southern California Edison, the McDonald's Corporation, and it just seems to be doing great.

We asked him if he in any way wanted to interact with us and he said no. He seemed to be doing quite fine and was very happy, and I just view that as a perfectly good example of the free enterprise system working the way it is supposed to.

Mr. MCDADE. What reason would he have now? Southern California and McDonald's are using it, but do your evaluations point to the conclusion that it will result in that kind of savings in electricity and on all electrical motors?

Dr. MANNELLA. No. We have some perhaps different interpretations of the penetration of the market and the applicability of the device, but what we are saying is that surely in the installations that we have seen it does appear to save 15 to 20 percent of the electrical energy.

Mr. MCDADE. Would you say it is indeed a significant breakthrough in the conservation effort in this country in the use of electricity?

Dr. MANNELLA. Well, significant? It is a very good piece of work. It seems to be a very worthwhile thing to do. How widespread it will be, how much energy it will actually wind up getting saved and what not I think will determine whether or not it is significant. It is potentially significant, can I say that?

Mr. MCKAY. Yes. You already have.

Mr. MCDADE. Yes, you can. Here is a guy who finally pulls that rabbit out of a hat, I thought, but he didn't. You don't know.

Mr. McKay. It strikes me this agency is very conservative on their judgments of other people's data. Go ahead, Mr. Duncan.

ELECTRICAL TRANSMISSION LINE POWER LOSSES

Mr. Duncan. I don't know whether this is in the line of conservation or not, but I think it is. We have got huge losses of electrical energy in transmission. I remember when we put in the intertie between the Northwest, we authorized two a.c. lines and two d.c. lines, and the advantage of the d.c. line was that you did not have the transmission loss.

It seems to me in my layman's mind I relate it to loss by friction. The disadvantage was the high cost of converting that power at the other end back into alternating current. We have within the jurisdiction of this committee the helium program. We apparently have quit conserving helium. We are wasting all this helium from those gas fields which is produced.

Someone has told me that if you can reduce the temperature of your transmission lines, that you have huge savings, and helium is a natural commodity used to induce that temperature, and it has bothered me that we are wasting all this helium to the atmosphere.

I guess you can get it back, but it is a tremendous cost in energy and money to do it. Do you have any comments at all?

Dr. Mannella. Yes, we have an extensive program in transmission and distribution which does not come under this committee.

HELIUM PROGRAM

Mr. Duncan. But the helium program does.

Dr. Mannella. That is correct, and we are looking at low temperature cables for efficient distribution of bulk power, both superconnecting cables which would be cooled by helium, at a somewhat higher temperature but still extremely cold, resistive cryogenic cables. We too are concerned about the possible loss of the helium that you are mentioning.

We have gone on record, I believe, with the Department of Interior, have we not, Dr. Belding, advising them or urging them to reconsider their decision to close the helium plant in Oklahoma.

Dr. Belding. That is right.

Mr. Duncan. If you have got some papers on that, I would like you to send them to my office tomorrow or the next day.

Dr. Mannella. We did a report on the helium supply in the United States.

Dr. Belding. ERDA 13. It was turned out 2 years ago at the request of the Congress, I believe.

Mr. Duncan. I am concerned about that. It just seems to me that year by year we are wasting a very, very, very valuable natural resource.

Dr. Belding. It turns out that we are dumping helium into the atmosphere, and the way we are doing it is kind of ridiculous. We are separating it out of the natural gas, which is expensive, and then we are dumping it into the atmosphere. If we are going to separate it out, we ought to go ahead and save it some way. If we are not going to separate it out, fine, just leave it in the natural gas. It doesn't hurt

anything, but to separate it out and then dump it into the atmosphere is kind of stupid.

Mr. DUNCAN. That was the initial impression I have had and I am glad that I am in agreement with ERDA on something.

Mr. MCDADE. Would you yield?

Mr. MCKAY. Yes.

ENERGY INTENSIVE INDUSTRIES

Mr. MCDADE. I was going to try to move from transportation to the industrial sector, and ask you whether or not you have tried to get into these terribly complex questions about industries which are energy intensive.

We read about the paper industry, the aluminum industry, the glass industry as being incredible users of energy. We sit on a committee here that appropriates a lot of money for the U.S. Forest Service. We sit on the committee that has that responsibility, and we constantly are arguing back and forth about how much money ought to go into that renewable resource, that I was always under the impression that was not for purposes of homebuilding.

Dr. MANNELLA. For pulping?

Mr. MCDADE. No, no, for the construction of homes, one of those high classified industries that use a lot of energy to create a home. I don't know whether that is right or wrong.

Dr. MANNELLA. I am not quite sure I see the point you are trying to make. The process associated with forest products as very energy intensive is papermaking, pulping.

Mr. MCDADE. I am not talking about pulping at all.

Mr. MCKAY. With the kiln drying process.

ENERGY CONSUMED IN BUILDING INDUSTRY

Mr. MCDADE. I am talking about using a resource to construct buildings. I am thinking of the home industry largely, and I am thinking about the wood products industry vis-a-vis, the energy required to create a home using a large amount of aluminum. I am sitting here thinking of buying aluminum siding for my house. They make it now in plastics, petrochemical stock.

I don't know where you end up with brick and the rest of it, but is there one industry that is energy conscious, energy conservationist more than the others with respect to the construction of a home?

Mr. DUNCAN. You mean which one uses the least energy?

Mr. MCDADE. That is what I am trying to say.

Dr. MANNELLA. Do you have an answer, Dr. Savitz?

Dr. SAVITZ. We have a contract with Dr. Bruce Hannon of the University of Illinois and Mr. Richard Stein, a New York City architect, in developing a technique that will do those trade-offs. Up to now there has not been such a tool. We can make energy embodiment comparisons say between wood, brick, aluminum siding. The model at its current stage of development tells us what type of components and buildings are the most energy intensive to construct and the least energy intensive to construct.

It is interesting to note that, from a construction point of view, the building of a home takes the least amount of energy on a per square foot basis. The building of a laboratory takes the most by a factor of four when compared to a home. The laboratory has more energy intensive products, such as sophisticated equipment, aluminum ducts, metal and steel and, or, concrete structures.

Now that this energy embodiment model is developed, we are going to the next step and within each of the individual buildings to do analysis as to the optimal energy house to build or optimal office to build, from a materials point of view.

We also have to consider the cost in addition to the energy. One could have the most energy efficient building from a materials standpoint, but these materials might add so much cost to construction that the normal homebuilder would not use them as he would have a house too expensive to sell.

Mr. McDade. Do you consider the renewability of the resource?

Dr. Savitz. The energy embodiment model goes back to whether one can start with scrap or raw material. We look at wood as a renewable resource. The energy necessary to grow wood is considered in the same way one considers the energy required to manufacture bricks, cement, or steel. The report concludes that 9 percent of the total U.S. energy requirement is used by the construction industry of which 80 percent is in embodied energy for materials.

Mr. McDade. And whereabouts are you with respect to this study, how far down the road?

Dr. Savitz. The model has been developed and utilized for analyzing 18 different types of buildings. A residence takes less energy than an office building.

Mr. McDade. Any kind of residence?

Dr. Savitz. Single family home.

Mr. McDade. No matter what you make it of?

Dr. Savitz. Yes.

Mr. McDade. But you haven't competed the various potentials.

Dr. Savitz. We are competing the various potentials. We have compared various components, like different types of insulation, different frames for storm windows, aluminum, wood, and the like. We have analyzed some of the individual components that go into a building. The first part of the study is available.

Dr. Mannella. What frequently happens is that any differences in the energy requirements to make a device that essentially consumes energy are very, very small compared to what that device consumes over its lifetime, and this is true for automobile engines, for homes, particularly more so for homes because they tend to last 50 or 60 years, something of that sort, so there may be differences in initial construction, but it is during the lifetime that it consumes many, many times more energy, which goes to say that a good design pays off in the long run.

ENERGY EFFICIENCY OF BUILDING COMPONENTS

Mr. McDade. Then what about the same question with respect to which components of a home tend to be more helpful with respect to lowering that operational cost? Do you have those studies done at all?

Dr. MANNELLA. As a matter of fact, we are working on various projects and some hardware associated with optimizing those kinds of things. One of the things we are doing is looking at what we call integrated appliances, which tends to use, for example, some of the waste heat from a refrigerator to help preheat the water for the dishwasher.

That seems to be ideally suited for mobile homes because they do tend to have a very compact integrated set of appliances which they just sort of buy as a unit and put in a mobile home. It turns out that most of the lower priced homes in the United States are mobile homes, most of the homes under say $25,000 or $30,000, but beyond that we are looking at things like heat pumps as replacements for furnaces and air-conditioning units, and trying to broaden the range of geographical coverage and whatnot, where heat pumps would be attractive, both from an energy standpoint and from an economic standpoint, trying to see if, for example, gas-fired heat pumps could be developed which would be suitable for some of the more northern parts of the United States.

They have traditionally been used in the more southerly parts. The reason is that in the heating mode the electric heat pumps make up the heating load with electrical resistance heating which is a terribly inefficient way to heat but in a gas-fired heat pump you can use the waste heat, so to speak, from the gas firing to help you with the heating load.

The gas-fired heat pump looks like it might be much more widely geographically acceptable in the United States. The bulk of the energy that is used in a residence is used for heating and cooling, so we have a very big effort in heat pumps, and the President's initiatives statement increases our thermally activated heat pump program by $2 million for 1978.

CONTEXT OF INVENTION PROGRAM IN THE OVERALL CONSERVATION PROGRAM

Mr. MCKAY. You had an earlier comment that you wanted to make.

Dr. MANNELLA. Yes; there was a point I would like to make. I almost hate to bring this up, but it does relate to the inventions program. The concern on the part of the committee is well taken by us. We too are concerned, and I know you are disappointed in the way the things have turned out so far, but the point that I wanted to make a little bit earlier in the discussion is please don't judge the entire 1978 conservation program by these several things in the inventions program which I am the first to admit could have been handled a little bit better. We have spent a lot of time and made a very substantial effort in trying to focus this program from where it was 1 year ago, and we have, I think, developed very distinct major thrusts in each of the four areas, linked rather rigorously through analytical studies to maximum energy savings, and we think we have come an awful long way.

I would just simply urge you to really look at the development of the program in the budget per se and not to judge us in light of the inventions program.

REQUEST TO OMB FOR CONSERVATION

Mr. YATES. OK, we won't judge you only on that.

Let's talk about OMB. How much money did you ask for from OMB?

Dr. MANNELLA. This program has gone through some substantial gyrations since last summer, Mr. Chairman. Our fiscal year 1977 appropriation is in the neighborhood—I will have to speak in terms of the entire conservation program, which includes the other two aspects, the other two program areas for the moment.

Our 1977 appropriation is $160 million. We originally asked OMB for $273 million for fiscal year 1978. That did not include the electric and hybrid vehicle program, which at the time we put the budget together had not been enacted.

The energy extension service, which at the time we put the budget together looked like it was going to become part of the ERDA authorization, was included in that request.

The Ford-OMB mark was $158 million. In other words, it was essentially a level funding program. The Carter-OMB mark restored essentially the $273 million that we originally asked for and added $40 million for the electric and hybrid vehicle program to bring it up to $318 million as of the middle of February.

Last week the initiatives associated with the policy statement added another $7 million to that, $2 million in gas fired heat pumps, $3 million in small fuel cells for apartment buildings and schools, and $2 million for the recovery of waste heat from our gaseous diffusion plants. The total now is $325 million.

Mr. YATES. You weren't really badly hurt, then, were you?

Dr. MANNELLA. In balance when you look at it we came out in pretty good shape although we had some difficult times in between.

Mr. YATES. And you were able to convert OMB?

Dr. MANNELLA. I can't really take credit for that. I think the President is going to have to take credit for that.

Mr. MCDADE. Would you yield, sir?

Mr. YATES. Yes.

Mr. MCDADE. Always trying to ask the question, however, whether or not in your judgment in this critically important area there are items with a good chance of success that you feel ought to be included that are not because of OMB's ultimate decision.

Dr. MANNELLA. No; I don't think there are any items of the sort that you described that are not included in here. It has not precluded us from any particular area that we feel very strongly about in terms of its potential.

DEVELOPMENT OF ELECTRIC VEHICLES

Mr. YATES. I am concerned about the fact that you are developing an electric vehicle and isn't the Department of Transportation concerned with that?

Dr. MANNELLA. No; the Department of Transportation, from which I came, has done nothing in the way of electric vehicles.

Mr. YATES. How about Mr. Brogan?

Dr. MANNELLA. No; he came from the Environmental Protection Agency.

Mr. YATES. Where did I see you? In the transportation subcommittee? Did I ever see you?

Mr. BROGAN. No.

Dr. MANNELLA. I brought Mr. Esposito from the Department of Transportation.

Mr. YATES. It was under the Hansen committee.

Dr. MANNELLA. The only thing I know of that DOT has done in the electric vehicle area is the provisions of VEPCO, which set the minimum fuel economy standards, did direct the DOT to determine whether or not minimum fuel economy standards should pertain to that type of vehicle.

Mr. YATES. Will your development of the electric vehicle be influenced at all by the article which appeared in this morning's paper which I am sure you read about the new electric motor?

Dr. MANNELLA. We had previous discussion on that. I just wanted to indicate that we had discussed that in a somewhat different context. That doesn't really have much attraction for electric vehicles.

Mr. YATES. You would need an awful long electric cord for it.

ELECTRIC VERSUS SYNTHETIC FUELED AUTOMOBILES

Mr. MCKAY. The Stanford Research Institute has given synthetic fuels an edge over electricity as a power source for future cars. What does that mean about electric cars in the future, or have we got bad information? Will liquid fuels through time still be the major power source?

Dr. MANNELLA. I think the major rationale for the electric vehicle is that it provides surface mobility, surface transportation, with something other than liquid hydrocarbon fuel, which is going to be in very great demand during the 1980's and the 1990's.

It allows you essentially to power your cars with hydro or nuclear or coal. It also has attraction in certain metropolitan areas that have very bad ambient air quality situations. It would seem to be ideal.

Mr. MCKAY. It has nothing to do with efficiency?

Dr. MANNELLA. It terms of efficiency on balance it is not really any more efficient than the new heat engines that we are going to be putting out at that time that it is going to be competing with, but it does ease the problem of availability of liquid fuel.

Mr. MCKAY. Of course, unless you come up with a self-generating electrical system within——

Dr. MANNELLA. You mean a hybrid-type vehicle?

Mr. MCKAY. I am only supposing here. I am not an inventor, but you have either got to plug them into an electrical system which is fired by hydrocarbons, or else you have got to create a self-generating system within itself.

Dr. MANNELLA. It would not be fired with gasoline. It would be fired with coal, nuclear or hydro, and those are fuels that are going to be more in abundance than gasoline.

Mr. MCKAY. But at some time they will come to this point, too.

Dr. MANNELLA. Our analyses seem to indicate that the crunch is really to come on the liquids.

Mr. MCKAY. I don't question that.

OMB REDUCTION IN TRANSPORTATION PROGRAM

Mr. YATES. OMB cut out $14 million from your transportation fund, didn't they? Will you be hurt by that?

Dr. MANNELLA. I am not sure of the set of numbers that you are referring to. Is that the budget history data?

Mr. YATES. What programs did they cut out?

Dr. MANNELLA. What that essentially covered was that in addition to the requirements of the Electric and Hybrid Vehicle Act, we were thinking in terms of doing substantially more research and development than is called for in the act, and those funds would have been applied in that area.

Mr. YATES. May I ask Mr. Greer to suggest a fund, appropriation for a fund of the kind that we talked about before to take care of the contingency you mentioned before. You may want to think about it overnight and let us know tomorrow morning.

OBLIGATION OF CONSERVATION FUNDS

You have only obligated 20 percent of your available funds so far, $21 million out of $101 million. You want an additional $25 million in a reprograming action. How do you expect to obligate over $100 million in 7 months when you have only obligated $21 million in 5 months?

Dr. MANNELLA. We tracked this pretty carefully, Mr. Chairman. Last year, for example, we did obligate I believe something in excess of 98 percent of our funds. Where we stand as of the end of March is as follows:

Of the $101 million available, we have internally authorized—that is, have procurements and what not in the process—for $87 million, and it is a matter of the procurement system working out the details during negotiations and what have you.

In addition, the $25 million should not present a problem for the following reason: $5 million of that is for HUD.

Mr. YATES. Wait a minute. $25 million isn't the problem. The problem is $100 million. You have obligated $21 million, and you have still got, at least at the time of the justification, $100 million to obligate. Are you saying at the end of March you have obligated 75 percent of it?

Dr. MANNELLA. No; I am saying at the end of March we have authorized, because we don't actually do the negotiations and whatnot, but we have authorized, put together the various paperwork and packages and whatnot to get obligated about 80 percent of the available funding.

Mr. YATES. You have already.

Dr. MANNELLA. $87 out of $101 million has been authorized.

Mr. YATES. That leaves you with $25 million to obligate.

Dr. MANNELLA. No; that leaves us with about $14 million to authorize.

Mr. YATES. You should be able to do that.

Dr. MANNELLA. I don't see any problem.

FISCAL YEAR 1977 REPROGRAMING FOR ELECTRIC AND HYBRID VEHICLE PROGRAM

Mr. YATES. Will you be asking for any reprograming?

Dr. MANNELLA. Yes; we do have a request for a $25 million reprograming in 1977.

Mr. YATES. Some of them were for fuel cells, weren't they?

Mr. GREER. $20 million for the Electric and Hybrid Vehicle Act and $5 million for building performance standards.

Mr. YATES. $20 million for the electrical vehicle. I am a little skeptical about the electrical vehicle. What are you going to have when you are through with it?

Dr. MANNELLA. The electrical vehicle program—

Mr. YATES. I happen to have seen a documentary that indicated you would have a tremendous energy problem with it.

Dr. MANNELLA. What we are doing primarily is implementing the provisions of the electrical vehicle act, which was passed last September, vetoed, overridden by the Congress. We have in addition to that a small baseline program, where independent of the demonstrations and the things required in the act, we are engaging in the overall design of an optimized electric vehicle.

Just to give you a feel for the relative amounts, in 1978, we are requesting a total of $46.9 million for electric vehicles; $40 million of that is for the electrical vehicle act. The bulk of that is for technology development and the first demonstration of 2,500 cars; $6.9 million is our baseline program.

BATTERIES FOR ELECTRIC VEHICLES

Let me address the batteries. We are using as much of the battery technology that goes on in our storage division that you referenced earlier as we can here. However, that program is really oriented towards some longer term, rather exotic batteries, lithium sulphur, and sodium sulphur.

To support from a storage standpoint the provisions of the act, we are going to have to use some shorter term options, primarily advanced lead acid batteries, typically the type you have in your automobile, and possibly some other versions, nickel, iron-nickel, and zinc, and included in that $20 million for fiscal year 1977 is about $9 million for battery work.

The battery issue is kind of a classical one. It just sort of depends on how you view the role of the electric vehicle. If you view the role of the electric vehicle as being essentially a one-to-one replacement with the internal combustion-engine-powered car, then it does require a fantastic battery, maybe beyond our ability to ever perfect, for the simple reason that you can store more energy in a tank of gasoline than you could conceivably store in an electric chemical system of any sort that has ever been discussed.

If, on the other hand, you look at it from an energy conservation standpoint and say 40 percent of our travel consists of trips 20 miles or less, which could at least theoretically be provided by an electric vehicle, then it does give you some reason for supposing that some figure, perhaps 20 percent of the fleet in 1990 or the year 2000, could

be electric vehicles, used primarily for the short-range type of trip, for commuting, for neighborhood trips or what have you, and not being a one-to-one replacement for the type of vehicle that can go 300 miles at a speed of 55 plus on a superhighway.

SCOPE OF ELECTRIC VEHICLE R. & D.

Mr. McKAY. You made the statement earlier in effect that you had intended to do a broader scheme of research than the act limited you to.

Dr. MANNELLA. That is right.

Mr. McKAY. Are you indicating to us that you would have come up with a better product had we not limited it?

Dr. MANNELLA. The act is very specific about certain things. The act is very specific about loan guarantees for the electric vehicle industry. It is very specific about the two demonstrations; the timing and the size of the first demonstration of 2,500 vehicles, and the timing and the size of the second demonstration of advance vehicles of 5,000.

The act also requires us to do certain vehicle components and battery R. & D. and our "druthers" were to do a substantial amount in that area because it tends to maximize the success of the program.

In the judgment of other folks who look at the budgets in total, it was thought that we really didn't have to do that much in order to be responsive to the act, and to have a viable program. It is a judgment call.

Mr. McKAY. So you wouldn't necessarily then come up with any better product?

Mr. MANNELLA. I can't guarantee. We would have put more R. & D. money into a couple of crucial areas and perhaps increased our chances of success.

Mr. McKAY. Now you are limited in doing that.

Dr. MANNELLA. Somewhat, yes.

Mr. McKAY. The implication of that is we may have built in defeat, or at least not what we intended it to comply with.

Dr. MANNELLA. I am not that pessimistic about it. I think that the intent of the act is to find out what the institutional and real world problems are with the use of electric vehicles. Will people buy them? Will they drive them? Are they reliable? Can you get them licensed? Can you get them insured? Can you get them repaired? We have built up quite a tremendous infrastructure around our internal combustion engine vehicles that we sort of take it for granted.

We have really got to go out and find out what it is going to take to do essentially the same thing for electrical vehicles and try and determine how much of an advance is going to be required to see these used in large numbers.

I think we are going to find that out, and I think it is going to be beneficial in that regard.

Now, whether or not the second fleet really has the super best batteries that could possibly be developed or not, and whether that is going to make the difference between success and failure, I just can't see it quite that clearly. We would like to have the best hardware that we could.

Mr. McKAY. This was aimed strictly at electrical cars.

Dr. MANNELLA. Plus hybrids.
Mr. MCKAY. Plus hybrids?
Dr. MANNELLA. Plus hybrids.

HYBRID VEHICLES

Mr. YATES. What do you mean by hybrids?

Dr. MANNELLA. A hybrid can be almost anything that you want it to be because it is a very elastic kind of term, but basically what it means is something other than batteries, something in addition to the batteries, and the type of hybrid that we are most keen on is where you would have a very small gasoline engine, lower horsepower, 15 or 20 horsepower gasoline engine, and you would run that at constant speed and it operates efficiently at constant speed.

It is the slowing down and accelerating or whatnot in your gasoline engines which give you the inefficiencies. By running that at constant speed through a generator, you could either provide electricity, which would drive the vehicle directly, or provide electricity which could charge the batteries, and drive the vehicle.

The advantage of this is that it extends the potential range of the electric vehicle rather substantially, for the reason that even a few gallons of gasoline can carry two or three times the amount of energy that you can store in battery packs.

Mr. MCKAY. Would this hybrid include, what is the one they have been playing around with, that the environmentalists talk about, going on the principles of many of the older John Deere tractor? It has got a flywheel momentum type of thing, the old John Deere put-put-puts along but when the power take-up is there, why that takes it on.

Dr. MANELLA. Maybe it is just splitting hairs. I wouldn't call it a hybrid, but the flywheel could have a very distinct role here because the flywheel allows you to do regenerative braking. When we have a vehicle that is traveling at a high speed, and you slow it down with your friction brakes, you transform all of the kinetic energy of that vehicle into heat of your brakes, which you can't recover. If you store it in the flywheel, then you can use it when you accelerate again, and it makes the overall process very efficient.

We have negotiated with the Post Office to put flywheels in several of their electric jeeps that they are running as part of their 350 or so vehicle fleet. They do have some electric jeeps out on the west coast. We have had flywheels in two subway cars in the New York Transit Authority checking out some of the problems and materials characteristics, but essentially doing the same thing.

When a vehicle slows down, instead of dissipating its kinetic energy as heat, you put it back into the flywheel, store it there, and use it again when you accelerate.

When you have a stop-start type of thing in a Post Office vehicle—and Mr. Brogan indicated this is the perfect example of this—it smooths that out and makes it look like a fairly continuous operation.

ACCOMPLISHMENTS IN CONSERVATION PROGRAM

Mr. MCDADE. Mr. Chairman, could I just ask one brief question. You have described the one major impact you had, and we credit

you with that in the industry where you recycle heat that is burned off. What others have you got, finished products, working today, that you can say conserves petroleum? I know that is a hard question.

Dr. MANNELLA. There aren't very many. The program is only a couple of years old, and the nature of the technology is that it takes a couple of years to develop and a couple of years to get out. We do have a few things.

Mr. MCDADE. If you have some that are of specific interest that are dramatic like that one, briefly describe it. If you would prefer, do them for the record.

Mr. MANNELLA. I would be happy to put them in the record, if I may.

[The information follows:]

PROJECTS CONSIDERED SUCCESSES AND THE RELATED RATIONALE

Although the Division of Industrial Energy Conservation has projects currently on contract only one demonstration project has reached the phase where success can be defined. This is the fuel-saving system for curing coil-coated finishes, a retrofit system for metal coil coating lines which incinerates the paint fumes within the curing ovens to provide up to 80 percent of the curing heat. Even though the official start of this demonstration is May 27, 1977, when the remaining equipment element is installed—a waste heat boiler—the eight zone incinerators (replacing natural gas burners) are installed and operating off paint fumes with gas savings of 68 percent even without the waste heat boiler. A further indication of success of this project is the ordering of two other systems within the industry and numerous inquiries by others on the strength of the results to date of the ERDA/Industry program.

Other nondemonstration project successes to date include completion of a detailed compilation of data and second law analysis that provides a process matrix by order of energy losses. This shows (within the 10 most energy-intensive industries studied) the most promising targets for conservation efforts.

A second example of a successful study is the completion of a study of conservation potentials in the paper and steel industries again providing project targeting data vital to program planning accuracy.

In summary and in view of the low relative age of the Division of Industrial Energy Conservation an aspect of success is evidenced by the planning of some 122 active projects in fiscal year 1977 including competitively-selected efforts in industrial waste heat recovery, cogeneration, industrial, and agricultural process improvements.

Mr. MCDADE. Why don't you do them with the permission of the chairman back where you described the success that you have had with the industry?

Dr. MANNELLA. I will be happy to.

Mr. YATES. I think you ought to describe the success you have had to a much greater extent than you have told the committee today. You may want to amplify that for the record. I don't know whether you were requested to do it before, but I think it would be helpful, at least certainly for Mr. Duncan's peace of mind, to explain what happened to those 27 inventions.

Dr. MANNELLA. We will be providing that for the record, also, Mr. Chairman.

ENERGY EXTENSION SERVICE

Mr. YATES. Now let's talk about the Energy Extension Service. What mechanisms do you currently use for technology transfer?

Dr. MANNELLA. I wonder is Dr. Willis still here? Judy Liersch is here. I wonder if I could turn to her?

Mr. YATES. The question, Judy, is what mechanisms are currently used for technology transfer?

Ms. LIERSCH. In the Extension Service?

Mr. YATES. Yes; in the Energy Extension Service.

Ms. LIERSCH. We have been relying extensively on the published documents that are available, particularly from FEA and from ERDA, and have compiled them into a bibliographic form that can be used by the average householder and lay person.

Mr. YATES. Does it relate in any respect to what FEA does?

Ms. LIERSCH. Yes; it does.

We have been working very closely with the State conservation programs of the Federal Energy Administration. Dick Vannoy is the program manager in charge of the State conservation program provided for under the Energy Policy and Conservation Act of 1975, and the followup legislation in 1976.

We have a cosigned agreement on precisely how we will work together. The target audiences on which we are focusing are in some cases very similar.

The Energy Policy and Conservation Act has five mandatory conservation focuses in it. These are not, however, the type of outreach activities where ERDA's program would overlap with FEA's.

Mr. YATES. And you have an agreement with FEA as to your respective roles?

Ms. LIERSCH. What we are doing, Mr. Chairman, is that we have an arrangement whereby FEA will review the proposals we receive from the State. First of all, we are requesting of the States a certification in the proposals they write to us that they are not asking for funds to duplicate any activity already funded by FEA.

Furthermore, their proposals will be reviewed by FEA to validate that certification, if you will.

I also sit on their review panel to look at the funding they are doing.

Dr. MANNELLA. The key to the Energy Extension Service, as Ms. Liersch says, is an active outreach type of program rather than one that merely provides written information. We have some studies under way at New York Institute of Technology and Texas A. & M. to determine the best means of doing this, both in an urban an a rural type of setting. The rural type of setting, for example, might be patterned after the Agricultural Extension Service, which seems to be quite successful.

Mr. YATES. What about the school workshops?

Ms. LIERSCH. The proposal by the way, that is, the solicitation document, Mr. Chairman, is due to go out at the end of this week. We suggest some areas that the States might be interested in pursuing but we do not emphasize the school program.

Mr. YATES. You are not in that then?

Ms. LIERSCH. No. We are not prescribing for the States, Mr. Chairman, specific programs. We are stating to them that we would like to hear what target audiences they would like to reach and what kind of services they would like to provide.

Mr. YATES. You are starting with the kids and educating them on energy conservation. Is that the idea on this? Is that the purpose of going to the schools?

Ms. LIERSCH. Yes. I haven't got as far into those programs as I have the State conservation programs.

Mr. YATES. All right.

Would you place in the record the major accomplishments to date of what your program has done?

Ms. LIERSCH. Certainly; I will be glad to.

[The information follows:]

PLANS FOR IMPLEMENTING THE ENERGY EXTENSION SERVICE

In conformance with the legislation presently under consideration, ERDA is implementing the EES on an initial basis. The initial program will involve approximately ten States to be selected competitively. The competitive State solicitation, issued on April 29, was prepared with input from the National Governor's Conference and from FEA. Attached is the ERDA milestone chart for EES implementation.

State EES proposals in response to the solicitation will be submitted by June 30. ERDA anticipates that winning states will be awarded funds in mid-August, with detailed implementation planning and state operations to follow thereafter.

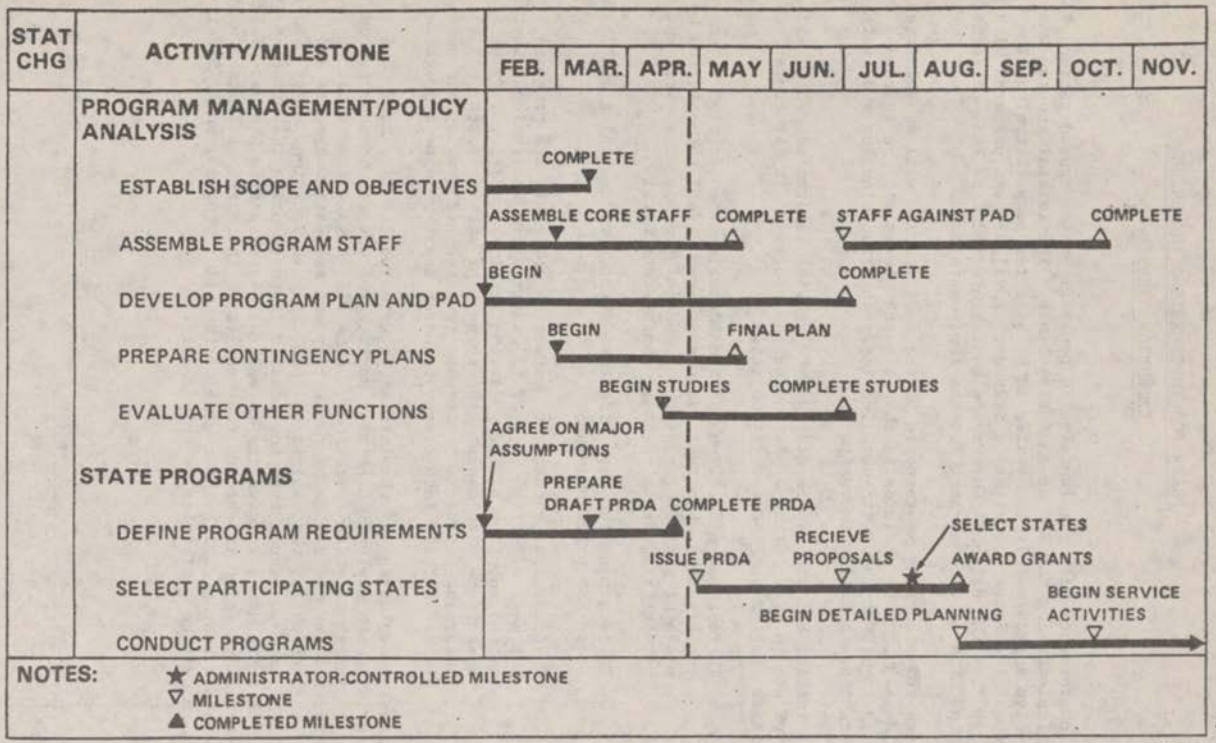
The initial EES program is desinged to provide information which will be of use in structuring a nationwide EES program. In particular, the initial program has three major objectives:

- To test the effectiveness of encouraging the adoption of energy conservation opportunities and renewable fuel technologies by means of providing assistance and information on a local and personalized basis to small energy consumers;
- To determine the most effective methods of designing and operating State EES programs; and
- To determine, within the context of the State EES programs, the most effective ways of (1) identifying insitutional barriers to the adoption of energy-saving measures, (2) identifying issues associated with consumer acceptance of such measures, and (3) obtaining feedback on consumer research and development needs to be factored into energy research and development programs.

Intensive evaluation of the initial program results is a high ERDA priority, with evaluation forming an integral program component from the beginning of state operations. ERDA will engage contractor assistance for the design of monitoring and evaluation systems and for the conduct of the evaluation process. In addition, every effort will be made to assure that the lessons learned during the pilot program will benefit non-participating as well as participating States. Selected States will assist in sharing the results of their EES activities with the other States during the course of the pilot program, and ERDA also will undertake activities in this regard.

ENERGY EXTENSION SERVICE

APRIL 27, 1977

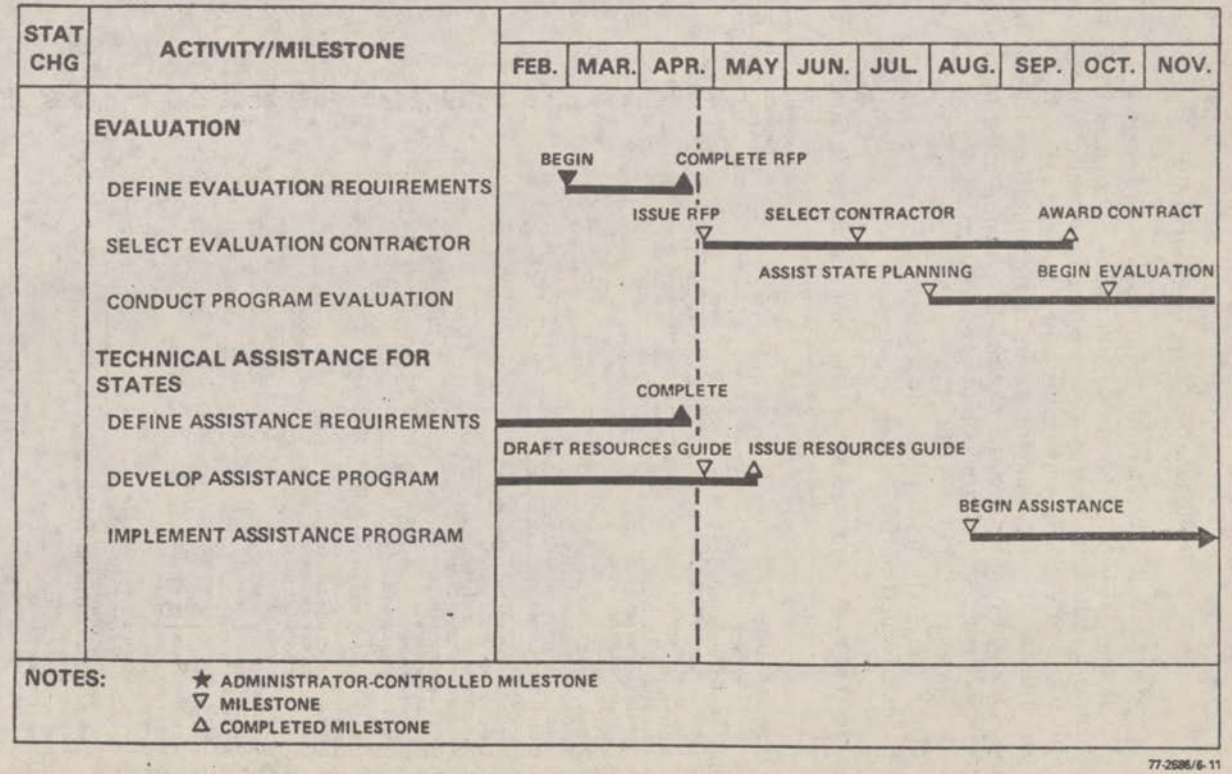


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ENERGY EXTENSION SERVICE

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Mr. YATES. Thank you.

INDUSTRIAL ENERGY CONSERVATION

Mr. YATES. Let's turn to industrial energy conservation.

On page 9 of the justifications you make a statement that 30 to 50 percent of industrial energy usage could be saved through universal application of existing, emerging, and advanced technologies. That is a substantial amount, amounting to 12 to 20 million barrels of oil a day. Can you provide for the record at this point a list of your major projects, their cost, and the potential energy savings?

Dr. MANNELLA. Yes; we can.

Mr. YATES. All right. Please do it then.

[The information follows:]

SUMMARY OF FISCAL YEAR 1978 PROJECTS FOR THE DIVISION OF INDUSTRIAL ENERGY CONSERVATION

Project description	Fiscal year 1978 obligations (thousands)	Estimated total savings potential (10^{15} Btu/yr)
1. Catalytic combustion/boilers	(1)	(1)
2. Follow-on demo/boiler fuel control	300	0.77
3. Fabric filtration	300	.04
4. Insulation study	100	(2)
5. Refractories study	150	(2)
6. High-temperature recuperators	1,400	2.10
7. High-temperature heat pumps	1,400	1.10
8. Stirling cycle heat pump study	60	(2)
9. Organic rankine bottoming cycle	500	2.00
10. Brayton cycle in glass industry	800	.30
11. Inplant power generation study	100	(2)
12. External desulfurization	150	.10
13. Blended cement	150	.30
14. Program management and system analysis	435	(2)
15. Energy monitor in oil refinery	428	.48
16. Carbon monoxide as a feedstock	300	.20
17. Nitrogen-based carburization	600	.09
18. Energy management in paper plants	200	.14
19. Dry coke quenching	200	.10
20. Energy-integrated industrial park	600	.42
21. Coal in aluminum remelt	650	.10
22. Metals extraction	340	.04
23. Industrial materials and waste systems	1,392	1.56
24. Low-energy silicone production	80	.02
25. Improved radiant tube furnace	100	.03
26. Electric arc furnace modification	100	.01
27. Alternates to natural gas/paint	500	.03
28. Oxygen-enriched combustion	100	.20
29. Continuous casting/steel	1,400	.12
30. Direct reduction/aluminum	1,800	.90
31. Acetylene from coal	2,400	.09
32. Electric arc welding power supply	100	.13
33. Fuel-fired scrap heater	250	.09
34. Aluminum smelter modification	740	.30
35. Fuel saving paint curing system	600	.16
36. Glass conglomerates	250	.03
37. Moving beam furnace modification	100	.23
38. Computer controls/small chemical plants	150	.08
39. Paper pulp fiber characterization	100	(2)
40. Food packing and preservation alternatives	550	.05
41. Irrigation systems	550	.36
42. Heat pump grain drying	605	.02
43. Whole milk sterilization	300	.06
44. Nitrogen fertilizer production	500	.50
45. Textile process modification	360	.05
46. Textile hyper-filtration	300	.04
47. Poultry processing modification	200	.01
48. Headbox for paper processes	400	.04
49. Foam fiber technology	500	.10
50. Plate food recovery	400	.05
51. Mechanical dewatering/paper	100	.06
52. Workshops	100	(2)
53. Energy/economic analyses	100	(2)
54. Energy savings potential analyses	160	(2)
55. Project reliability analyses	50	(2)

See footnotes at end of table.

SUMMARY OF FISCAL YEAR 1978 PROJECTS FOR THE DIVISION OF INDUSTRIAL ENERGY CONSERVATION—Con.

Project description	Fiscal year 1978 obligations (thousands)	Estimated total savings potential (10^{15} Btu/yr)
56. Project screening	130	[2]
57. Exhibits	60	[2]
58. Agri-Mod analysis	100	[2]
59. Data base/materials optim	220	[2]
60. International data base	150	[2]
61. Completed projects reports	100	[2]
62. Capsule reports	40	[2]
63. Seminars	100	[2]
64. Contractor performance evaluation	50	[2]
65. Energy impact scoreboard	50	[2]
Total	25,500	

[1] Project recently canceled.
[2] Not applicable.

EXISTING CONTRACTS WITH INDUSTRIAL CONTRACTORS WHICH WILL CONTINUE INTO FISCAL YEAR 1978

[Dollar amounts in thousands]

Number and project description	Budget authority funding		Total estimated savings (10^{15} Btu/year)
	Industry	Federal	
1—Powered handtool study		$170	(1)
2—Fuel-saving paint-curing system	$550	400	0.16
3—Moving beam furnace	549	860	.23
4—Boiler air/fuel ratio controls	25	289	.77
5—In-plant power generation study		90	(1)
6—Distillation energy study		112	(1)
7—Energy monitor in an oil refinery	213	531	.48
8—High temperature recuperators	775	3,113	2.10
9—Industrial heat pumps	810	2,700	1.10
10—Aluminum smelter modification	1,414	4,734	.30
11—Program study—Erecon		30	(1)
Total	4,336	[2] 13,029	

[1] Not applicable.
[2] This excludes new initiatives planned in fiscal year 1978 in the amount of $11,971 which would bring the total industrial energy conservation effort to $25,000.

PROJECTS BEING PURSUED BY INDUSTRY

Mr. YATES. You say there are significant areas that industry is already pursuing. Would you provide that for the record as well?

Dr. MANNELLA. Be happy to.

[The information follows:]

PROJECTS BEING PURSUED BY THE INDUSTRIAL SECTOR ON ITS OWN

A complete listing of projects of industrial energy conservation which are being pursued by the industrial sector without Government support is not available. Much of the private sector effort is proprietary in nature and a detailed tabulation of known, nonproprietary programs would be extremely lengthy and would include the "housekeeping" activities—light control, increased insulation, correcting steam leaks, et cetera, as well as retrofits of off-the-shelf recuperators, waste heat boilers, et cetera.

Historically, industry has actively pursued conservation activities which entail low-to-moderate technological risks, require modest capital expenditures and have high return on investment. The result of each effort since 1950 has averaged about 1.5 percent reduction in energy consumption per unit of output. The ERDA role is the sharing of risks in developing and demonstrating new technology for energy conservation having higher risk, higher cost, but potentially higher energy savings if successful. A second role of ERDA is the acceleration of the date of implementation of the new technologies.

POTENTIAL ENERGY SAVINGS OF INDUSTRIAL PROJECTS

Mr. YATES. Now let's take a look again at pages 12 and 13. On pages 12 and 13 there is a series of statements here that really don't mean

anything without an indication of what their impact is likely to be quantitatively. Can you put that in the record too as well?

Dr. MANNELLA. You are talking about the energy savings associated with each of those?

Mr. YATES. Yes.

Dr. MANNELLA. We will be happy to.

[The information follows:]

Energy savings associated with the accomplishments listed under the industrial energy conservation justification in the President's fiscal year 1978 budget

Number and project description	*Estimated total potentail savings~ 10^{15} Btu/year*
1.—Fuel saving paint curing system	0.16
2.—Boiler air/fuel ratio control system	0.77
3.—High temperature recuperators	2.10
4.—Industrial heat pumps	1.10
5.—Coal for aluminum remelt	0.10
6.—Energy-integrated industrial parks	0.42
7.—Glass conglomerates	0.03
8.—Fabric filtration	0.04
9.—External desulfurization	0.10
10.—Industrial materials and waste systems	1.56
11.—Crop irrigation systems	0.36
12.—Poultry process improvement	0.01
13.—Mechanical dewatering/paper	0.06
14.—Headbox for paper processes	0.04
15.—Textile process modifications	0.05
16.—Foam fiber technology	0.10
17.—Whole milk sterilization	0.06
18.—Food packing/preservation	0.05
19.—Nitrogen-based carburization	0.09
20.—Direct reduction/aluminum	0.90
21.—Continuous casting of steel	0.12
22.—Aluminum smelter modification	0.30

INSULATION IN THE INDUSTRIAL SECTOR

Mr. YATES. Under waste energy reduction and utilization you talk about insulation development. Are insulation suppliers doing anything in this area?

Dr. MANNELLA. I will turn to Mr. Harvey for that. Can you answer that, Doug?

Mr. HARVEY. The problem with insulation today is that in the industrial sector there is a relatively poor quantification of the actual value or conductivity value associated with insulation. It is a very difficult factor to measure, No. 1, and No. 2, if the insulation is not installed correctly then the K value is relatively meaningless because as moisture penetrates the moisture barrier around the high temperature steam line insulation or refrigerant insulation, the value of the insulation goes down significantly. So in this area we have first a round-robin program to evaluate weight variation measurement techniques for determining what adequate K measurement techniques might be, trying to develop a standard technique for measurement of both high- and low-temperature industrialization.

In the second area we are looking at alternate vapor barriers with much higher reliability. One of the problems today is the insulation manufacturers properly manufacture most of the products, but they cannot guarantee them because they cannot guarantee the installation.

If that vapor barrier leaks, forget it. The installation really is not very good. That essentially is what we are doing.

Dr. MANNELLA. It is essentially a paper study, in the neighborhood of $1,000.

Mr. MCKAY. Cannot we get some information relative to this last year? We were talking about this, and they were coming to the point of standardization of how much thickness of fiberglass or other things would create a certain insulated circumstance and were grading that, as I recall it, on a 1 to 20 scale. I don't remember exactly now.

Mr. HARVEY. The program that you are talking about was one of Dr. Savitz's programs, the buildings and community systems, I believe. I am talking about industrial insulation. These are high temperature or low temperature insulation that are installed on steam lines or refrigerator lines, or on furnaces. They are considerably different than standard utilization used in the home.

Mr. MCKAY. But it seems to me there ought to be some relationship. If you have some insulation that becomes the high heat and low temperature there should be some relationship to that because it is a different volume or intensity of heat and temperature in the home, but it is the same principle.

Mr. HARVEY. It is exactly the same principle, sir.

Mr. MCKAY. So somewhere there ought to be some relationship in that study to where homes could pick it up and maybe they would be better off, because you could have maybe one volume. Half of that would be adequate for homes and get all the insulation needed.

Dr. MANNELLA. This material probably tends to be rather expensive for residences. You put a premium on material, for, say, very high temperature lines in an industrial setting, whereas the conventional fiberglass might be quite suitable for residences.

Mr. YATES. Are you using fiberglass for your cars too?

Dr. MANNELLA. Not necessarily entirely.

Mr. MCKAY. Your paper fibers——

Dr. MANNELLA. Cellulose.

CELLULOSE AS INSULATION

Mr. MCKAY. Cellulose. That is a better insulation?

Dr. MANELLA. I would like to have Dr. Savitz comment on that. She has been quite involved in this. Dr. Savitz is quite up to date on this.

Dr. SAVITZ. We did a study of cellulose looking at some of its properties. It is known to have a very good value as an insulating material, but there are some concerns about how well it will hold up, particularly if you are really starting with a paper product and you treat it with various additives for five retardation, and there is concern that some of these fire retardants could actually dissolve if there was moisture content around. Insulation could be sitting outside before it was put in and there is some seepage, and we have done a survey of about 20 different samples that have 6 different types of additives. Six different chemicals have been added to it and it really is a problem that we all have to be aware of, particularly as we start to promote tax credits for homes in the sense that some of these cellulose materials do look like they are treated with certain sulfate compounds that will absorb moisture and absorb it in 28 days sitting out, will promote fungus growth. That is not true of all cellulose materials. Those treated with a borax and/or carbonates are very good and hold up.

We are following on this study and these were sort of done off-the-line factory samples and now we are trying to go back and look at some that have been installed, and we have some data from some of the States where they have had some insulation program, get material out and see what has happened over time.

The Canadians have just issued a performance standard for cellulose materials. There is currently no performance standard here for that.

The Consumer Products Safety Commissioner has looked at all types of insulation material for homes, fiberglass to true cellulose, and has said they are all effective except for a couple of the cellulose ones which they are holding in abeyance.

Mr. McKay. I have an old home out there, and I have one section which I put in last summer in the house which looks like almost ground-up paper, which we blew in.

Dr. Savitz. It depends on what that was treated with.

Mr. McKay. Of course, I don't know.

Several years ago I put in some cellulose which looks like it is stripped or hammered pieces of timber, limbs or something. It is kind of fiber, and it has held its content, but you are telling me that heat and cold, even though we are in a dry situation, may absorb a certain amount of moisture.

Dr. Savitz. Well, this depends on how well again it was installed, and what the situation was. If you have a leak in your roof and you have the insulation under your roof, you may have some moisture.

Mr. McKay. Until summertime that gets up to 200 degrees temperature, and in wintertime it gets the opposite.

Dr. Savitz. The heat will not bother it. It is the moisture that is the concern.

Mr. McKay. Normally if you have it completely isolated from the moisture you are probably all right is what you are telling me?

Dr. Savitz. That is right.

Mr. McKay. And the fiberglass is equally good as long as it doesn't——

Dr. Savitz. The fiberglass is more moisture retardant. There does not appear to be the problem with moisture in fiberglass as there has been with the cellulose.

Mr. McKay. Has there been a recent change in the treating of the cellulose over what it was 5 years, or 2 years, ago? Is it still the same old stuff?

Dr. Savitz. There have been a lot of different ways of treating cellulose. Different companies treat it with different kinds of chemicals for fire retardation, whereas fiberglass, no matter whom you buy it from, it has been made by the same process, and that is a difference.

With cellulose you can pick half a dozen off-the-shelf chemicals to make fire retardant.

Mr. McKay. I can tell you whether it is effective or not as I looked over the roofs of the neighborhood those who had insulation and those who didn't, where the snow was staying on, and the others weren't. That may be one gauge to tell whether it is scientific by volume and time.

Dr. Savitz. That is a very quick and easy way to determine how effective your insulation is.

Mr. Yates. By looking at the snow?

Dr. Savitz. Yes. If the snow melts quickly that means the heat is escaping off.

Mr. Yates. All right.

FOLLOW-ON DEMONSTRATION FOR BOILER FUEL/AIR RATIO CONTROL

On page 16 of the justifications you ask for a second demonstration of a boiler fuel/air ratio control system. Why do you need another one? Wasn't the first one satisfactory?

Dr. MANNELLA. I am going to have to turn to Mr. Harvey for that.

Mr. HARVEY. The boiler fuel/air ratio control meter is applicable to multiburner industrial burners, or it is applicable to direct heating systems and they are considerably different systems. The first demonstration will be in a boiler system located in a major industrial plant in California, and the objective of this program is to adjust accurately the air/fuel ratios such that you get complete combustion of the fuel within the proper region of the boiler to get maximum energy out of it. We expect it will save about seven percent of the boiler fuel energy.

Now, the direct heating application is a very significantly different system. Here, like in a glass lehr which is the oven for a plate glass system, they will have 400 to 500 burners instead of four burners. The adjustment of the air/fuel ratio where this is a very much higher temperature operation, the reflected radiation from the lehr is very much higher than in the case of a steam boiler.

The economic effectiveness of this system will vary in accordance with the applications, so we are looking at it for oil-fired and gas-fired systems in steam boilers and primarily for gas-fired systems in direct heating furnaces.

Mr. YATES. All right.

Mr. HARVEY. The first one I think will be successful.

Mr. YATES. Is it operating now?

Mr. HARVEY. No, sir, not yet. It will be operating hopefully by September. We should have demonstrated performance data within 2 months after that.

Mr. YATES. Mr. McKay.

Mr. MCKAY. This is strictly for big commercial operations?

Mr. HARVEY. Yes, strictly big commercial boilers, 100,000 pounds per hour steam boilers.

IN-PLANT POWER GENERATION

Mr. YATES. What is the potential for energy savings in the in-plant power generation discussed in your justification?

Dr. MANNELLA. That is substantial, Mr. Chairman, because this particular item is a study that relates to cogeneration and the cogeneration of electric power and steam is a technique that has come under a lot of favorable review, and there are literally thousands of instances, locations, in industry where the requirements for both electric power and steam exists side-by-side. If you generate the electricity as a remote central power station you have little or no opportunity to use the steam.

Mr. YATES. Isn't cogeneration a common practice in Europe?

Dr. MANNELLA. It is, much more common than here.

Mr. YATES. What is the R. & D. here?

Dr. MANELLA. It is not really R. & D.

Mr. YATES. Is it cheaper to send you to Europe and keep you there for a couple of weeks than pay for this?

Dr. MANNELLA. It is not R. & D. In the sense of starting from the beginning and trying to figure out how to cogenerate. What it does try to do is to identify the particular locations where we hope that it will be economically attractive and to look at the various types of cogeneration options that exist. There are a lot of different ways that you can cogenerate.

Mr. YATES. Why don't you provide a resume of it for the record?

Dr. MANNELLA. We have a report on this subject that we would be happy to include in the record.

[The information follows:]

COGENERATION REPORTS

The attached include a recent report by Thermo Electron Corp. and three reports by Douglas G. Harvey on this subject of cogeneration.

Summary Assessment of Electricity Cogeneration in Industry (Thermo Electron).

Cogeneration of Electricity and Process Steam (Douglas G. Harvey).

Cogeneration (Douglas G. Harvey).

Projected Penetration of Cogeneration Systems (Douglas G. Harvey).

SUMMARY ASSESSMENT OF ELECTRICITY CO-GENERATION IN INDUSTRY

COGENERATION OF ELECTRICITY AND PROCESS STEAM

Problem: The simultaneous production of process steam and electricity (cogeneration) by industry represents a major underutilized energy conservation opportunity.

Proposal: To overcome the technical, institutional, and economic barriers which currently preclude extensive utilization of cogeneration.

Discussion: The Federal role in promoting industrial cogeneration must take three simultaneous paths:

1. Technical: Prove through demonstration programs the reliability, performance, and economics of cogeneration in at least four major industries: Pulp and paper; petroleum refining; chemicals; and steel. These demonstrations must emphasize the use of low premium fuels such as coal and residual oil.

2. Institutional: Examine and develop legislation to change the current legal infrastructure at the local, state and Federal level which currently discourages cogeneration.

3. Economics: Develop a body of Federal incentives (which may include energy tax penalties and tax credits) which improve the current economic benefits of cogeneration, such that industry will rapidly adopt the desired mix of cogeneration systems.

In the detailed formulation of these actions, it is essential that each be constructed to promote the use of coal and residual oil and reduce dependence on natural gas and distillate. The program would require 10 years to implement due to the requirement of providing demonstrated performance data in each of the industries involved. The fuel savings accruing from this project would depend on the degree to which the technology penetrates the industrial market. The range of fuel savings after 10 years is estimated to be:

Estimated Penetration	Installed Capacity Mw(e)	Energy Savings (BPDE)
High	59,000	700,000
Prob.	42,000	500,000
Low	28,000	300,000

The estimated costs of the production of a corresponding level of electricity with and without cogeneration is shown below:

	Costs				
	Federal	State	Private (Billions)		
	$ (Millions)	$ (Millions)	High	$ Prob.	Low
Without Cogen	0	0	66	47	28
With Cogen	500	10	40	28	17

George Hall
Energy Policy and Planning
Staff

PROJECTED PENETRATION OF COGENERATION SYSTEMS

At Jack Silbey's request, I asked Resource Planning Associates (RPA), one of our quick response contractors, to evaluate the penetration of cogeneration systems in the 1985 time period based on: Thermoelectron's Report (TE5429-97-76); Tom Widmer's paper; and RPA's current survey of industrial firms and their interest in cogeneration (FEA Contract). In the short time available, RPA was only able to evaluate penetration in the chemical industry. A 50 percent tax credit incentive was used for the RPA forcasts.

In conducting this work, they used as a baseline the TEECO data on total steam use in the chemical industry and then subtracted out various factors perceived to be inhibiting functions. Two mixes of cogeneration were used - the RPA forcasted mix and the TEECO forcasted mix. Enclosure 1 summarizes the results obtained. Using the RPA mix (explained on the second sheet of Enclosure 1) the level of penetration is 20 percent of the TEECO forecast. Using the TEECO mix the penetration is about 39 percent of the TEECO forcast. Backup details and assumptions may be found in Enclosure 2.

Assuming that this penetration comparison were applicable to all the industries studied by TEECO the following comparisons can be made.

	TEECO 40% Tax Incentive	RPA 50% Tax Incentive (TEECO Mix)	RPA 50% Tax Incentive (RPA Mix)
Forecast (1000 BPDE)	600	234	123
Forecast Capacity (MW)	40,000	15,600	8000

This confirms the value selected by your staff of 2000,000 BPDE

The RPA estimate of Federal costs for the 50 percent investment tax credit is $124 million tax revenue loss (see Enclosure 2).

Douglas G. Harvey
Director
Division of Industrial Energy
Conservation

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HIGH TEMPERATURE HEAT PUMPS

Mr. YATES. What do you mean by coefficient of performance with relation to heat pumps?

Dr. MANNELLA. It is essentially the efficiency of the unit. The higher the coefficient performance the better.

Mr. YATES. Are there savings in this program?

Dr. MANNELLA. We think the heat pump has an awful lot of attractions because you are essentially extracting heat from ——

Mr. YATES. Attractable to safe engineering too.

Dr. MANNELLA. We think it has the potential to save a lot of energy.

RANKINE BOTTOMING CYCLES

Mr. YATES. Why do you need five separate projects to demonstrate generation of electricity by the use of Rankine Bottoming Cycles?

Mr. MANNELLA. There is a variety of different types of applications, a variety of different temperatures of exhaust streams, variety of different environments of the exhaust streams, and we feel that this is the way to develop technology that would serve across the board.

INDUSTRIAL PROCESS EFFICIENCY

Mr. YATES. Can you provide a list showing the budget authority for each project under the industrial process efficiency?

Dr. MANNELLA. Yes, we can.

Mr. YATES. Showing the amount of industrial cofunding and the potential energy savings?

Dr. MANNELLA. You mean the existing contracts?

Mr. YATES. Yes.

Dr. MANNELLA. Yes, we can.

Mr. YATES. All right.

[The information follows:]

EXISTING INDUSTRY CONTRACTS FOR INDUSTRIAL PROCESS EFFICIENCY, FISCAL YEAR 1978

[Dollar amounts in thousands]

Number and project description	Budget authority funding		Total estimated savings (10^{15} Btu/year)
	Industry	Federal	
1. Powered handtool study		$170	
2. Fuel-saving paint-curing system	$550	400	0.16
3. Moving beam furnace	549	860	.23
4. Distillation energy study		112	
5. Energy monitor in an oil refinery	213	531	.48
Total	1,312	[1] 2,073	

[1] This excludes new initiatives planned in fiscal year 1978 in the amount of $11,507 which would bring the total industrial process efficiency effort to $13,580.

ENERGY AUDIT IN OIL REFINERY

Mr. YATES. To what extent is industry involved in your project to provide an energy audit of refining? Why is the Government involved in that kind of project?

Dr. MANNELLA. Refineries do consume a lot of energy in processing the crude to gasoline.

Mr. YATES. Why is the Government involved in this kind of project?

Dr. MANNELLA. It is an attractive target for energy savings and energy savings of liquid fuels which have a premium on them.

Mr. YATES. All right.

Dr. MANNELLA. The energy that is consumed in a refinery may not be obvious because you are not buying it or buying very much of it from someone else. You are really using incoming stock to provide an awful lot of energy.

ARC WELDING POWER SUPPLY

Mr. YATES. What kind of breakthroughs do you expect in the arc welding power supply since no change has taken place in the last 40 years?

Dr. MANNELLA. I don't know whether we can qualify that.

Mr. YATES. Maybe this is the year.

Dr. MANNELLA. I am sure that not much has been addressed in the way of resources to this area. Maybe with the resources we are talking about here we will see a breakthrough, although it is a very modest program, again $100,000.

ENERGY OPTIMIZED INDUSTRIAL PARK

Mr. YATES. Assuming you can develop plans for the energy optimized industrial park, how do you expect to persuade industry to adopt the plan?

Dr. MANNELLA. I think this is where we would link the industrial program with Dr. Savitz's community energy systems program because when you look at energy usage in a very broad scale and you optimize the energy flow in the industrial park then you take the residual heat and use it for direct heating in the adjacent community.

Mr. YATES. Why do you need to fund a demonstration?

Dr. MANNELLA. Just simply because you have to tie all these things together and show the benefits and try to quantify the benefits that derive from it.

INDUSTRY FUNDING FOR CONSERVATION TECHNIQUES

Mr. MCKAY. Excuse me just a minute. It strikes me if industry is so tied to the dollar and the making of the dollar, and the potential exists for these kinds of things with the adjacent community, it seems to me that somehow they would have pursued that, or hadn't it ever hit anybody's conscious mind in all the brainpower of some of these corporate——

Dr. MANNELLA. It is not that novel or new in concept. It is hard for industry to make money by energy conservation because the portion of the class of your product attributable to energy is much lower than it is to labor and materials. Aluminum is about the most energy-intensive product from a cost standpoint we have.

Mr. MCKAY. You are saying they have all kinds of energy so they don't worry about that as a cost factor.

Dr. MANNELLA. I am saying they have other ways than investing in energy conservation, shorter payback periods and higher probability of success.

Mr. McKay. But if you listen to these people they are scratching every penny and mile out of everything they can to make the profits come out for investors.

Mr. Yates. Second, if that were true, why are you spending all this money?

Dr. Mannella. Because we think the time will come, and shortly, when either through lack of availability and/or cost that we will have to turn to these options and institute them very quickly. We do not in those cases see industry investing the R. & D. dollars in these things. Anything that they are investing money in we are very glad to get out of.

Mr. Yates. Does that makes sense? The thesis of Government is that if energy costs go up people will lose energy, and I will think that no matter how little attention industry pays to energy now because of the other costs, if the costs go up substantially they are going to pay attention to it, and the costs are going to go up substantially, aren't they? They have gone up substantially in many industries.

Dr. Mannella. Energy is still a much less costly item than many other factors that industry can opt for, such as labor, and we are still traditionally using cheaper energy in place of say labor and materials in many instances.

Mr. Yates. You are going against the teachings of Frank Zarb and against the teaching of James Schlesinger, who say if the costs go up people will use less.

Dr. Mannella. That is true, that in general as the costs go up they will use less. What we are talking about in industry is not using less through curtailment, which is different than I think what we are talking about in the private area.

What we are talking about is using less per unit of product, using it more efficiently. We are not talking about cranking down the GNP. We are talking about the same goods and services, but in a more energy efficient mode, which requires investment.

Mr. Yates. I would have thought that the controllers and the auditors in industrial companies would see the rising curve of energy costs and would start telling the operating executives that they better start thinking about it.

Dr. Mannella. Well, I think there is a growing awareness, but if you have energy costs in the neighborhood of 10 percent of your product your payback period for capital investment to reduce energy costs is going to be like 8 years. You have to compete for those dollars within a corporation for product development and new product where they look for like a 40-percent return on investment.

Mr. McKay. I saw a notation somewhere of a study which indicated in Europe when their prices went up it had a momentary effect on reduction and usage of energy, but it went right back up again. They adjusted themselves, made their adjustment, and the consumption didn't stop.

Dr. Mannella. You are talking about gasoline specifically.

Mr. McKay. Yes, oil and gas products, which then says that the thesis of Zarb and so on is only going to be temporary and the price factor may just crank in a little inflation and we may have to go to some other sources and routes than we are talking about here to save the energy rather than the price factor itself.

Dr. MANNELLA. To the extent that price increases it makes conservation technology more attractive because the payback period keeps decreasing.

Mr. MCKAY. That may be for industry if they are really serious about it except they just crank it in and pay it off to the consumer and if the consumer is willing to adjust to it in a short period of time we haven't accomplished much.

PRODUCTION OF ACETYLENE FROM COAL

Mr. YATES. In your justification you have a project for production of acetylene from coal. Why do you handle this instead of Dr. White?

Dr. MANNELLA. That project actually had its beginnings in the Office of Coal Research in the Department of Interior prior to the formation of ERDA. In the fossil program they have reoriented their program somewhat away from this sort of end use application and actually encouraged us to look at it from our industrial classification standpoint, which we did. It is very attractive because acetylene can be a feedstock for many different types of chemicals, such as vinyls, and would hopefully displace some of the demand for feedstock from petroleum.

INTERACTION WITH METAL PROCESSING INDUSTRY

Mr. YATES. What is the reaction of the metal processing industries to your program?

Dr. MANNELLA. It varies somewhat. I think that the aluminum industry is very enthusiastic about our program. They realize that they are tied to a specific form of energy and even in the Northwest where there has been traditionally lots of relatively low-cost electric power they are now foreseeing the possibility that it might not be available or as available and they are willing to work with us.

PROJECT SELECTION PROCESS

Mr. YATES. How do you decide which projects to work on? Who knows about all these things? I am impressed by the scope of the various kinds of projects that are listed here like the low-energy silicone product, improved radiant tube furnace, nitrogen-based carburization of steel parts, direct reduction of aluminum.

How do you get to know about a particular project so that you can prove it? Do they write in to you?

Dr. MANNELLA. It is a combination of things. We get unsolicited proposals. We have Program Opportunity Notices where we seek or solicit responses and we have RFP's. In the selection we have developed an internal screening process which seeks to balance the anticipated technological success, the cost of the market presentation, and the quad impact of energy savings in some sort of common formula so we can pick the things that are most attractive. Also, when we need specific information on a specific thing we have a number of consultants, usually in the academic world, who are very knowledgeable and frequently in possession of rather narrowly held data which we can go to and say, please tell us whether technologically this has ever been done, or whether it has any problems in it that you see to help us screen it.

Mr. YATES. On what basis do you decide that projects substituting another fuel, like coal for oil and natural gas, belong in conservation rather than fossil energy?

Dr. MANNELLA. Again, I think it is somewhat of an arbitrary kind of decision as to whether you are looking at it from the standpoint of the production or the supply of coal, oil, natural gas, or utilization in an industrial environment, and in the case of the acetylene project, for example, it seemed like that technology that was required there was not the same technology that is associated with the supply side, the fluidized bed combustion and things of that sort, but rather in the application of the product to the acetylene process.

WHOLE MILK STERILIZATION

Mr. YATES. I finally came about a project that I think I know a little about. That is the question of refrigerating milk. I am under the impression that milk spoils unless you refrigerate it. Here we find in your justification the whole milk sterilization; studies on nutritional levels to be conducted so that institutional barriers can be removed to insure adoption of the new process. Methods of attacking consumer resistance to accepting a nonrefrigerated milk product from supermarket shelves. Milk products is milk.

Dr. MANNELLA. That is milk.

Mr. YATES. You are not going to refrigerate it? What are you going to do; drink sour milk?

Dr. MANNELLA. There is a tremendous amount of energy associated with the delivery of milk today. The bays in a supermarket are generally open, and you are essentially trying to refrigerate the whole interior of the store. There is a technique by which you can sterilize whole milk by heating it or treating it thermally in some way that will keep it whole and unspoiled for periods up to a week to 10 days?

Mr. HARVEY. A year.

Mr. YATES. We will be back. Take a break.

[Recess.]

Mr. YATES. Let's go back to the milk.

What does it taste like after a year, yogurt?

Dr. MANNELLA. The problems associated with treating milk this way have traditionally been color. It can tend to decolorize a little bit in the treatment process.

Mr. YATES. It turns brown?

Dr. MANNELLA. It turns a little bit brown, that is exactly right, and taste.

Mr. YATES. It has a brown taste?

Dr. MANNELLA. It just tastes different than what people are conventionally used to, but the process we have under development at the University of Maryland looks like it can overcome both of these problems. The milk does not turn color, it is white, and they are testing it on the campus, and the taste problem seems to have been overcome.

One of the things you do is you refrigerate the milk before you serve it, because part of the taste that kids are used to is the fact that the milk is cold. Throughout the whole storage period and whatnot it is unrefrigerated.

Mr. YATES. How much energy could be saved if milk can be stored without refrigeration?

Dr. MANNELLA. I don't have that number available, but we can get it for the record, Mr. Chairman.

[The information follows:]

WHOLE MILK STERILIZATION

Total Potential Energy Savings (10^{15} Btu/Year) : .06.

Phase I of this project will study the implementation of the whole milk sterilization process. Rigorous test on product taste, storage life and nutrition levels will be conducted so that institutional barriers (State, local and Federal) can be removed to insure adoption of the new process. Methods for attacking consumer resistance to accepting a non-refrigerated milk product from supermarket shelves will be determined. Phase II of the project will involve commerical demonstration of the process coupled with market testing to insure consumer acceptance of the modified product.

WHOLE MILK STERILIZATION

Mr. YATES. Are you going to buy nonrefrigerated milk?

Dr. MANNELLA. My family can probably match any others in milk consumption.

Mr. YATES. It looks like a lot of people will be going to powdered milk.

Dr. MANNELLA. I can take a look at the liquid milk first.

Mr. HARVEY. By 1985, 27,000 barrels a day.

Mr. YATES. Around 27,000 barrels a day.

Dr. MANNELLA. What kind of penetration?

Mr. HARVEY. Market penetration of 10 percent.

Mr. YATES. What do you do about disappointed cows?

Dr. MANNELLA. It shouldn't affect the cow one way or the other.

Mr. YATES. Do you think consumers will buy nonrefrigerated milk?

Dr. MANNELLA. We will find out.

Mr. YATES. What about the milk industry? Are they cooperating with you?

Dr. MANNELLA. As I said, we are working with the University of Maryland.

Mr. YATES. I know that. I am not talking about the University of Maryland. I am talking about the milk industry. Mr. Harvey shakes his head no.

Dr. MANNELLA. They are not cooperating with us at this point in time but it should help them cost-wise. It will cut down on refrigeration costs substantially.

Mr. YATES. What good is that if they can't sell the milk?

Dr. MANNELLA. We are assuming if the process is adopted they will be able to sell the milk or vice versa.

Mr. YATES. Are you going to have problems with consumers on the questions of accepting packages instead of cans?

Dr. MANNELLA. I don't think so. Freeze dried foods were introduced 10 or 20 years ago, and were quite well accepted except they tended to be too expensive.

Mr. YATES. We accept cartons for bottles now for milk, don't we?

Dr. MANNELLA. Yes.

Mr. YATES. We don't even have to see the milk any more.

Dr. MANNELLA. That is right.

PROJECT RELIABILITY ANALYSIS

Mr. YATES. Would you explain for the record what you mean by project reliability analysis?

Dr. MANNELLA. I will be happy to.

[The information follows:]

PROJECT RELIABILITY ANALYSIS

This effort for which initial plans are being formulated in fiscal year 1977 relates to the application of reliability-maintainability analysis techniques to selected projects of Industrial Energy Conservation to get an advanced estimate of downtime and/or hazards that could be anticipated from such programs. Projects that would logically receive such analysis would be characterized by relatively high complexity, high capital equipment cost, potential safety problems, new technology with relatively high risk and a direct linkage with the plant operation so that downtime could affect other plant operations and the related economics as well.

This activity is currently being defined but all of the details are not completed at this time.

INDUSTRY CONSERVATION EXHIBITS

Mr. YATES. Also state for the record the cost for exhibits by budget authority for 1976, 1977, and 1978.

Dr. MANNELLA. Zero in 1977, $60,000 in 1978.

Mr. YATES. What was it in 1976; zero too?

Dr. MANNELLA. Yes; it was zero in fiscal year 1976.

ENERGY IMPACT SCOREBOARD

Mr. YATES. Why are you waiting until 1978 to initiate an energy impact scoreboard? You are not prepared for it now?

Mr. HARVEY. We have only got one.

Mr. YATES. One what?

Mr. HARVEY. One project that impacts.

Mr. YATES. Which one is that?

Mr. HARVEY. The coil-coating program.

Mr. YATES. And everything else is in the middle or hasn't been completed yet?

Mr. HARVEY. That is right.

Mr. YATES. Work in process is the phrase I was thinking of.

GAS-FIRED HEAT PUMPS

Now we turn to Buildings and Community Systems.

You want $2 million for gas-fired heat pumps.

Dr. MANNELLA. Yes, sir. That is a $2 million increase. I believe we had $1 million in the original budget.

Mr. YATES. That is a $2 million increase.

Dr. MANNELLA. That is $3 million total.

Mr. YATES. That is an important operation?

Dr. MANNELLA. Yes. We think that heat pumps are very attractive for heating and cooling residences. Heat pumps have been used in the southern part of the country where they augment on a heating cycle with electric resistance heat, which is really not a very good way to heat. So they haven't been used much in the northern part of the country, but gas-fired heat pumps, where you could use the waste heat

from the gas-firing process, might be very attractive in a much bigger geographical area.

ENERGY SAVINGS IN BUILDINGS AND COMMUNITY SYSTEMS

Mr. YATES. You project saving 2,400,000 barrels a day by 1985.

How much of that saving is related to the projects that you talk about, and how much to alternative energy sources, like solar energy, for example?

Dr. MANNELLA. Alternative energy sources are not included in there.

Mr. YATES. They were not taken into consideration?

Dr. MANNELLA. No.

Mr. YATES. So it is all from these projects of yours.

Dr. MANNELLA. That is correct.

ENERGY SAVED FROM INSULATION

Mr. YATES. How much energy can be saved by merely insulating buildings to reasonable standards, without considering any R. & D.?

Dr. MANNELLA. I wonder if I could ask Dr. Savitz if she has a number on that, insulation of existing buildings.

Dr. SAVITZ. If you take all the items like insulating homes, storm windows, clock thermostat, you would potentially save up to 1.2 million barrels per day with 100 percent penetration.

Mr. YATES. Of every window in the country?

Dr. SAVITZ. In residential buildings.

Mr. YATES. Of every window in the country.

Dr. SAVITZ. In single family homes.

Mr. YATES. What about commercial, would there be a number on commercial?

Dr. SAVITZ. I don't have an exact number on commercial because of the fact that you don't do the types of retrofit measures in commercial because of the expense involved.

Mr. YATES. What are we going to do about the contemporary buildings, Dr. Savitz, like, what is it, those World Trade Centers in New York?

Dr. SAVITZ. They are actually doing some surveying now to see if they can do something about the energy management in those buildings. The World Trade Center building was built in an era when there was a lot of energy and it was low cost. For example, instead of every room having a separate light switch, as it is expensive to put wiring into every room, they have a lighting system that will turn on one quadrant at a time. What they are exploring now, are some type of computer or detection devices that can be put into a room that would determine if light was needed and automatically turn it on. There is some control technology that is needed. The hope is that there will not be such buildings built in the future. The work on standards and implementation of them will lead to more efficiently designed buildings.

MIES VAN DER ROHE DESIGNS

Mr. YATES. What are we going to do about Mies von de Rohe?

Dr. SAVITZ. He is not with us anymore. One can make use of the buildings design and aspects of his. For example, one could use the windows to provide daylighting. His buildings have many windows.

If you turn off the lights, use daylighting, get some good energy management into the buildings, you can reduce the energy used.

Mr. YATES. How many of such buildings were built with thermopane as opposed to ordinary plate glass? Very few?

Dr. SAVITZ. Very few in the commercial sector, because of the expense. In that sector they are interested in the lowest first cost possible. What we are seeing in new energy efficient buildings, like GSA, which Dr. Mannella mentioned, is thermopane and a lot of insulation. The cost isn't any greater than in standard construction because the mechanical systems can be that much smaller and so they save on the internals, such as mechanical equipment and duct work. If you design a building with energy as a factor, for the entire building shell and systems you can cut down on costs and save dollars.

Mr. YATES. There is no way of opening up the windows, is there?

Dr. SAVITZ. No. You may have the same problem we have in our building.

Mr. YATES. You can open these. They rotate. All you do is put a key in there and they open up. You don't have that in your building.

Dr. SAVITZ. We don't have that in our building.

Mr. YATES. You are going to have to be warm in the summertime.

ERDA/HUD INTERFACE ON BUILDING PERFORMANCE STANDARDS

Would you provide for the record an explanation of what ERDA does as opposed to what HUD does in the area of building standards?

Dr. MANNELLA. We will be happy to.

[The information follows:]

ERDA/HUD ACTIVITIES IN BUILDING PERFORMANCE STANDARDS

HUD under Public Law 94-385 is mandated to promulgate energy-use standards for new construction. These standards are to be performance in nature; that is, maximum design flexibility is to be allowed the architect, engineer, owner. The standards are being developed by collection of data on existing energy use in buildings, modeling current construction practice to see what well-built buildings could be held to, and by applying existing minimum property standards and ASHRAE 90-75 standards to prototypical designs.

The ERDA program is directed at establishing the base of scientific knowledge that will allow innovative designs and methods, processes and equipment to be utilized to meet the performance standard. It will also provide scientific data allowing for "tightening" of standards (in an economically sound basis) in future years. The ERDA program provides the tools to the building professions, such as the Cal-ERDA public-domain computer program, to meet HUD-promulgated standards. Using simpler standards (prescriptive) as a starting point, the ERDA program has established procedures and training materials and programs which have allowed for the existing code enforcement organizations at State and local levels of government to handle energy codes as part of their normal inspection and certification process.

The programs are complementary. HUD stays on a defined path to meet a legislated time of promulgation. The ERDA is concerned with the higher risk research activities.

HUD'S ENERGY CONSERVATION STANDARDS

Mr. YATES. What is the time frame for the HUD program to develop model energy conservation standards?

Dr. MANNELLA. Minimum energy conservation standards were accelerated 1 year by the President's energy policy, and are now at 1980, originally by 1981.

Mr. YATES. Why 1980? Why not 1979, for example?

Dr. MANNELLA. There is a substantial amount of background work that has to be done in order to base the standards on appropriate data and technology. We would like to have them as soon as possible. A 1-year acceleration seemed to be all that was prudent.

Mr. YATES. Why do you have to pay HUD $5 million to do it?

Dr. MANNELLA. Actually there is more than that involved in the development of the whole standards. HUD is primarily concentrating on standards for the residential buildings, and we are working on the commercial buildings. We also have the Bureau of Standards involved which really is doing a substantial amount of the technical work.

Mr. YATES. You have $5 million budgeted this year and $10 million budgeted in 1978.

Dr. MANNELLA. That is correct.

Mr. YATES. All this goes to HUD?

Dr. MANNELLA. That $15 million goes to HUD, that is correct.

Mr. GREER. Mr. Chairman, that $5 million is in the reprograming.

Mr. YATES. You developed a model code for energy in buildings. How is this tied to the HUD work?

Dr. MANNELLA. It, we hope, would be the basis that would be used for validating the design of a building under these standards. You see, these standards are not prescription standards. They are performance standards. We would propose that this program called Cal-ERDA, being developed jointly with the California Energy Office, would be the basis of validation.

Mr. YATES. What kind of work are you going to do in house on the building standards; just commercial?

Dr. MANNELLA. Yes.

Mr. YATES. What energy savings are going to be achieved by this? You gave the number about residential.

Dr. MANNELLA. Dr. Savitz?

Dr. SAVITZ. By 1985, 325,000 barrels per day equivalent would be saved by implementation of performance standards. Roughly 50 percent of the energy that is used now in buildings could be saved through good design.

BUILDINGS AND COMMUNITY SYSTEMS ACCOMPLISHMENTS

Mr. YATES. Let's turn to pages 34 and 35 of your justification.

You have a whole list of things, but you don't tell us what the significance of each of those items is.

Would you please place in the record what the impact of the item is expected to be?

Dr. MANNELLA. This is the list under accomplishments.

Yes, we will be happy to, Mr. Chairman.

Mr. YATES. You tell us what you have done but you don't tell us why it is an accomplishment.

Dr. MANNELLA. We will be happy to provide that additional information.

PROGRAM ACCOMPLISHMENTS

The items listed (attached) are treated or considered by the Program Office to be Accomplishments since they in general either indicate the completion of a planned key milestone in the overall program, or have made a significant contribution to the society as a whole.

For example, the first accomplishment:

> "In support of HUD, major RD&D activities continued to develop performance standards for buildings. One of the most significant elements this year was the development of a model code for energy for buildings which is based on the private sector standard ASHRAE 90-75 and which was jointly developed by the existing model code organizations."

has connected with it both aspects described above. It was a key milestone in the National effort to develop and implement energy efficiency standards for new construction. In addition, using the energy problem as the catalyst, for the first time all the existing model code organizations in the U.S. worked together to develop a single code; hence, beyond energy, this is now the forerunner of simplifying the entire building industry code process.

Completion of the residential ACES demonstrations are significant milestones; the data allowing for the next generation activity to be started in earnest and allowing us to move into the multifamily and commercial building sectors.

The thermostatic valves which can save large quantities of energy were subject to some sceptisism. A demonstration was required to validate ease of installation, reliability, energy savings, cost, etc., and this demonstration depended on installation of such valves in an appropriate demonstration complex, which was accomplished and data collected in FY 1977.

In this initial demonstration, a 16% energy savings was realized.

A significant accomplishment was, using the restaurant project as the catalyst, development of a partnership project as the catalyst, development of a partnership with N.Y. State Government to work together in R&D which provides for a channel to transfer results from research to use quickly. The restaurant showed a 25% reduction in energy consumption.

The research for the water heater retrofit kit was completed. Industry initiated marketing and has reported a sale of 40,000 units. The kit is being distributed through local hardware stores, by utility companies and by a major national retailer, Sears.

Development of the threshold screening and scoring model has allowed the Division to rationally and consistantly evaluate candidate projects for funding. It has allowed us to make cost/benefit tradeoffs to insure that the most cost effective projects are funded. The rationale for Government involvement is also explicitly considered to assure that duplication of effort with the private sector does not concur.

The two pilot outreach projects at New York Institute of Technology and Texas A&M have provided ERDA with valuable experience in designing, implementing, evaluating and maintaining energy extension service programs, as well as to obtain data on the energy savings impact of specific extension activities (e.g., audits, hot lines, seminars, etc.). These projects provided ERDA with case studies of their specific activities which included their design, cost, staffing requirements, problems encountered and their resolvement, and impact. These case studies were then made available to the Energy Extension Service Pilot States.

As noted from the above, all items listed as accomplishments are in one (or both) of the catagories initially mentioned: completion of a planned milestone and/or having made a significant contribution to society as a whole.

ANNUAL CYCLE ENERGY SYSTEMS

Mr. YATES. What is ACES?

Dr. MANNELLA. That is the Annual Cycle Energy System, the prototype building that we have down at the University of Tennessee, that has the water storage in the basement, and stores heat during the summer, cooling the house, and then draws heat during the winter heating the house. It seeks to balance on an annual basis the heating and cooling requirements of the house.

Mr. YATES. How is that done; by computer?

Dr. MANNELLA. No, it is just essentially using the water as a storage medium, of accumulating the heat during the summer and then drawing from it during the winter.

LITEK LIGHT BULB

Mr. YATES. I asked you about the screw-in fluorescent light bulb, and you said it was brought to an advanced stage of development. You must have retrogressed, because it was supposed to be ready either a year or two years ago.

Dr. MANNELLA. It is not ready yet. We are still working on it.

Mr. YATES. And it has potential.

Dr. MANNELLA. We think so. The 70 percent lower energy requirement makes it a very attractive but high risk type of project.

SEATTLE MUNICIPAL SOLID WASTE PROJECT

Mr. YATES. What is the Seattle project?

Dr. MANNELLA. That is a project whereby the city of Seattle is looking at the possibility of taking their municipal solid waste and disposing of it in such a way that they come out with ammonia as a product, ammonia being very desirable to use as a fertilizer. It is a very energy-intensive product. The bulk of the funds involved in this would be provided from the city of Seattle bonds. Our involvement is to help with some of the design and evaluation of this as a possible way of converting municipal waste into an energy-rich product.

Mr. YATES. What are you going to do about cows, Congressman Obey's cows and their waste?

Dr. MANNELLA. That is in the biomass program area, which is under the Solar Division.

MISSION VIEJO PROJECT

Mr. YATES. Would you explain in the record your Mission Viejo program and its success?

Dr. MANNELLA. We will be happy to.

[The information follows:]

MINIMUM ENERGY DWELLING (MED)

ERDA is sharing the costs of designing, building and evaluating two energy conservation demonstration houses (MED) at the Mission Viejo project in Orange County, Calif. The houses sell in the $40,000 price range and sales are quite rapid with some 9,000 units out of 30,000 units already built and sold. The participants with ERDA are the Southern California Gas Co., Mission Viejo and Burt Hill and Associates of Butler, Pa.

Southern California Gas has gathered this dynamic team of expert designers in energy conservation and the contractor is the 1976 National Home Builders' Association (NAHB) "Builder of the Year." The special design features in the ERDA cost-shared demonstration home will achieve over 50 percent in energy

savings as compared to the presently constructed "Cordova" model which meets HUD standards. The two houses are complete and data collection is underway. One house is occupied by a typical family for realistic energy conservation data. Both demonstration houses are being compared to a standard house of the same orientation and size and without the energy conservation features.

Special features include: (1) solar assisted hot water heating and cooling, (2) 500-gallon thermal storage tank, (3) extra heavy thermal insulation, (4) double-pane windows with solar shutters, (5) energy saving appliances, exteriors, and (8) night set-back thermostats.

MISSION VIEJO PROJECT

Mr. YATES. What features of that are readily adaptable by builders with little or no public resistance?

Dr. MANNELLA. Many of them. As a matter of fact the minimum energy development in Mission Viejo is a very simple combination of different techniques that can be readily adapted.

Mr. YATES. Will there be features that will be harder to implement?

Dr. MANNELLA. No, it is shuttering of windows, overhang of roof, very simple architectural features that we think can find ready acceptance in the market.

INSTITUTIONAL RESISTANCE TO ENERGY CONSERVATION

Mr. YATES. You are talking about institutional resistance to energy conservation efforts.

Is there a great deal?

Dr. MANNELLA. Yes; particularly when you get into some of the financing aspects of buildings and the types of information that consumers are or are not presented with, life cycle costing information is not available in many, many product areas, things of this sort.

Mr. YATES. How is your program designed to overcome this resistance?

Dr. MANNELLA. We are working with as many of the institutional forces as we can, the National Association of Homebuilders, and with HUD and with some of the lending institutions, and we have starting this year a life cycle costing demonstration in Denver, with the cooperation of a couple of large retailers like Montgomery Ward and Sears, to test whether or not the consumer can use the kind of information that might be available.

BUILDINGS DESIGN AND STRUCTURE

Mr. YATES. Let's talk about buildings, design and structure. You speak of retrofitting demonstrations for office buildings in the New York City area.

How many are we talking about?

Dr. MANNELLA. This is the study, that I mentioned earlier, being done by Syska, Hennessey, and Tishman Associates. I think we are looking at 200 typical office buildings, just to try to quantify what is available in terms of retrofit actions.

Mr. YATES. How long will the demonstration take?

Dr. MANNELLA. It is not really a demonstration. It is an assessment of the potential.

Mr. YATES. How long will the appraisal take?

Dr. SAVITZ. The appraisal will be ready in June and that will be followed by selecting some of the buildings from that data for further work.

Mr. YATES. How much money is involved in this?

Dr. SAVITZ. In that one it is $300,000.

Mr. YATES. Is industry contributing anything to that?

Dr. SAVITZ. We are getting some contributions on validation of energy use from Con Edison.

Mr. YATES. Why don't you and Mr. Harvey come to the table here, instead of hollering. We will even let you sit next to Mr. Greer, and we will let Mr. Harvey sit in Mr. Armstrong's chair. When you speak, speak to the reporter because he is more important than I am in this.

Had you finished your answer?

Dr. SAVITZ. Yes; Con Edison is doing this, and then the building owners, the fact that they are giving us the data and releasing it.

FUEL CELL TOTAL ENERGY SYSTEMS

Mr. YATES. Now you talk in your justification of studies about fuel cells, total energy systems.

What is the potential for this? Can you say there is a potential?

Dr. MANNELLA. Yes; substantial. With a gas-fired fuel cell in the 40 to 100 kW range for a typical building like a school or apartment building, it can provide electricity and space conditioning for 70 percent of the gas that it takes to heat the building alone, with a 30 percent reduction in gas, we can provide the electricity and all the space conditioning by using the waste heat from the fuel cell. We can convert that into barrels of oil per day savings.

Dr. BELDING. That is over a conventional furnace.

Mr. YATES. What time frame is involved here in getting results from the fuel cell?

Dr. MANNELLA. We are going to start the development of the 40 kW unit this year. It will be ready for demonstration in 2 years, John?

Dr. BELDING. We are going to have some in buildings within a year and a half.

ANNUAL CYCLE ENERGY SYSTEMS

Mr. YATES. I think I asked you about ACES, didn't I, put an explanation of that in the record?

Dr. SAVITZ. Yes.

Mr. YATES. Is the system more applicable to commercial establishments than private homes?

Dr. SAVITZ. ACES? Yes; it looks like it might be a little intensive for the private dwelling. It might be more applicable for garden apartments, institutional buildings, this sort of thing, more than one family.

Mr. YATES. When you put the explanation in the record, you will discuss the economics.

Dr. MANNELLA. We will do so.

[The information follows:]

Annual Cycle Energy System (ACES)

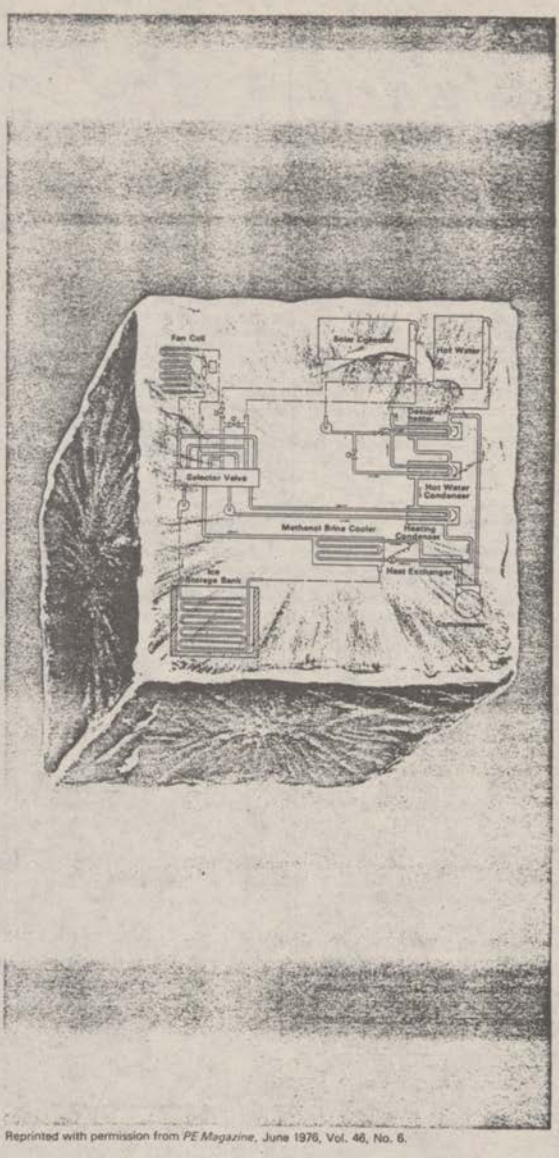
The Energy Research and Development Administration (ERDA) is providing research and development funding support to develop new energy saving technologies and to transfer those technologies to the private sector. One such program is an "annual cycle energy system" (ACES), which is designed to provide space heating, air conditioning and domestic water heating for residential and commercial application. The energy transfer is by an electrically driven heat pump in conjunction with an ice water solution stored in an insulated underground tank. As heat is extracted during the heating season, most of the water is frozen and the stored ice provides "free" airconditioning during the summer. As the ice melts, during the cooling season, heat is thus stored for winter extraction. For a properly designed building within an applicable weather zone, an annual cycle energy system (ACES) could save over 50 percent of the energy now used for heating, cooling and hot water.

One demonstration house has been completed in Knoxville, Tenn. It is fully instrumented to obtain all the technical data necessary to evaluate the system This data collecting process started during February 1977, with a full report available during the Spring of 1978. Other demonstration houses have been built and tested in Richmond, Va., and will be built in Philadelphia, Pa. These homes are owned by the private sector and will provide real life conditions.

An office building is now being recommended for selection by the Southern Interstate Nuclear Board (SINB) to demonstrate the feasibility of the ACES on a larger system.

Other Federal agencies are also investigating the ACES system. The Veterans' Administration has included it in the sixty (60) bed nursing home in Wilmington, Del. The construction contract was let on June 30, 1976. Performance data and summary reports will be made available in January, 1980. ERDA plans are now being finalized to develop a residential design handbook for nontechnical people and a commercial design handbook for engineers. Marketing surveys are now underway. Workshops have been held and more planned in fiscal year 1977–78. Research is also being conducted on more cost-effective energy components of the system like the compressor, pumps, storage tank, coils, single and multiplate ice makers.

The economics evaluation of the ACES program indicates a payback period of 9.87 years when the units are being mass-produced.



Ice & Water: Annual Cycle Energy System Offers Savings in Heating, Cooling

Union Carbide and Oak Ridge National Laboratory are well into an experimental heating and cooling system based on extracting the heat from water being turned to ice and then using the ice for summer cooling. Developed by Harry C. Fischer, an engineer and inventor with more than 50 U.S. and foreign patents in the HVAC field, the system is said to have the potential of energy savings of close to 70 percent in residential and commercial heating and cooling.

By H.C. Fischer
Consultant
Energy Division
Oak Ridge National Laboratory
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

The annual cycle energy system (ACES) offers an inexpensive means of providing heat from the latent heat of fusion of water. The ice frozen in the winter is then stored to provide "free" air conditioning in the summer. The annual cycle energy system works in the following manner:

1. Heat is obtained by freezing water to remove the heat of fusion (144 Btu/lb). The heat thus obtained is pumped by a one-direction heat pump to deliver heat to the building.

2. The ice frozen during the heating season is stored and used to provide air conditioning during the summer. The melting of

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the ice stores the summer heat energy in the water by increasing its enthalpy as it changes from solid to liquid state.

The cycle is repeated each year and the only major energy cost is that of operating the heat pump during the heating season. Since the heat pump operates between rather fixed limits of 20°F evaporating to 105°F condensing and since the system can be optimized for those temperatures, we can obtain a coefficient of performance (COP) of 3.5 on the heating cycle with present compressors and can reach, we believe, a COP of 4.0 with the new high efficiency compressors now coming on the market.

Since both the heating capacity and the cooling capacity of the heat pump are being used in the annual cycle system, the annual COP is calculated as:

$$\frac{\text{(heating)} \quad \text{(cooling saved)}}{\text{heat of rejection} + \text{heat of absorption}}$$
$$\text{electrical input in Btu}$$

This COP is reduced by pumping power and heat leakage into ice bin, which is approximately three percent of the bin capacity per month. The pumping power and the heat leakage into the bin reduce the ice available for cooling so that the actual annual COP for present technology is 4.25 and for the new high efficiency compressors is approximately 5.0.

On an annual basis, domestic hot water represents between 30 and 40 percent of the total heating requirements for a dwelling located between 36°N and 38°N latitude. Of course, it represents a smaller fraction as one moves further north.

When heating domestic water the heat source is again the freezing of water. Domestic hot water is held at 120°F minimum temperature throughout the year, although it may go higher during the winter because so much high-temperature superheated refrigerant vapor is pumped during the heating season.

During mild weather and summer months, the only reason for operating the compressor is to produce domestic hot water. The domestic hot water load will generally result in an operating time for the compressor of between two and three hours per day. The desired hot water temperature is approximately 120°F, and, therefore, the condenser surface is designed so that the condensing temperature is higher than it would be if space heating were required.

When the space heating coil is operating, the condensing temperature is approximately 105°F, and only the superheat from the high pressure gas is being used to heat domestic hot water. When no space heating is required the necessary temperature for hot water can only be reached by increasing the condensing temperature at which the heat pump operates.

The domestic hot water temperature will be kept a good deal lower than it would be with a conventional gas or electric hot water heater. However, no problems are expected since dishwashers are today equipped with "sanitizing cycles" that sterilize dishes with the heated air used for drying.

Large central system building assemblies using direct expansion refrigeration are manufactured by several large concerns including Crepaco, Chester Jensen, Dole Refrigeration, and L.V. Fleiter Company. Some of these systems have as much as 50,000 feet of tubing in the evaporator sections. Large ice-building systems are current state-of-the-art for many commercial applications.

Ice volume varies with climate and we feel that the ice volume should be sized to take care of the air conditioning requirements with capacity to spare. The water volume to be frozen must be adequate to carry the dwelling through the coldest twelve weeks of the heating season.

It is obvious that as one moves north the winter heating loads become greater and the summer cooling loads become less. If heating and cooling loads of residential buildings only are considered, the heating and cooling loads are about in balance (at latitude 38° North). If domestic hot water heating load is added to the space heating load the "balance point" moves south to about Nashville, Tennessee, (36°N latitude) for well insulated dwellings. The bal-

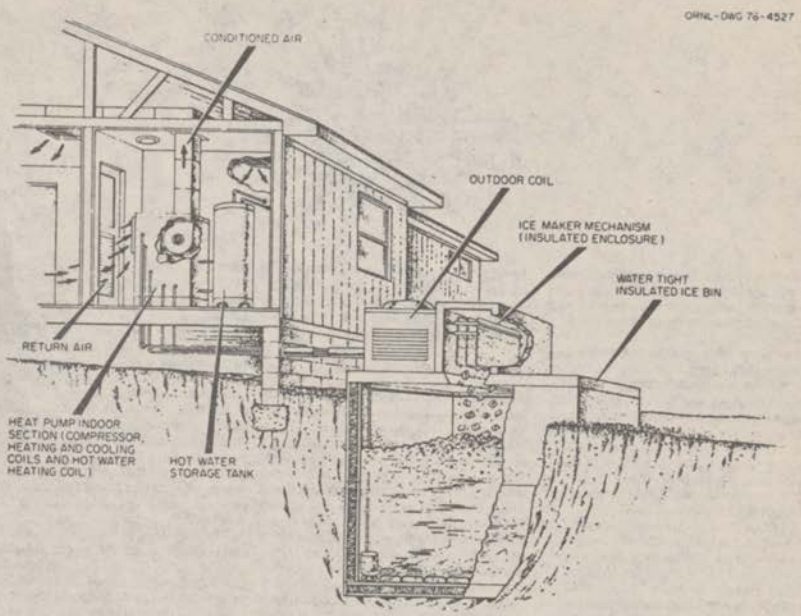
Thermally-Active Fabric Roof

In developing new office building concepts, GSA has actively proceeded with a study on megastructure technology. This concept for federal office buildings would incorporate a triple-layered, thermally-active, pneumatic fabric roof which permits winter sun radiation into the building and reflects summer radiation. We have named this concept "MEG 2" after the consortium of professionals who collectively were able to research and establish the feasibility of key areas of controlled-environment structures for federal office buildings. The building would exhibit several energy conservation features in a totally different building environment which offers many additional benefits.

The MEG 2 roof envelope is made up of three layers of fabric whose upper two layers are designed to be half reflective and half translucent. When the air between the upper two layers is evacuated, the middle layer rises and a reflective surface is formed over the entire roof area. The purpose of this roof mechanism is to admit solar energy into the space when conditions are favorable and to reject it when not needed. The solar radiation entering the space is absorbed by the internal structure and partly stored for later use.

Pneumatic roofs are built and bid competitively today. The MEG 2 pneumatic roof is feasible with technology available today and may be bid competitively after completion of the required adaptive engineering phase.

Nicholas A. Panuzio
Commissioner, Public Buildings Service
General Services Administration



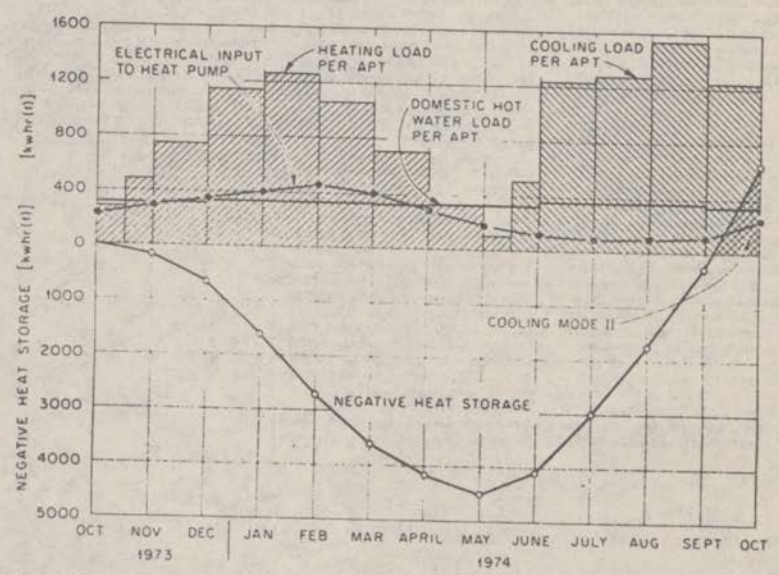
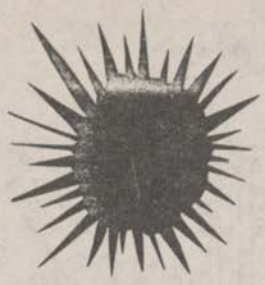


Figure 1. Annual cycle energy study. This study was based on actual energy use of a 406-apartment complex in the Washington, D.C. area—April 1973 to April 1974.



ance point for a poorly insulated house is further south than for a well-insulated one.

In areas north of the balance point, one must either build more ice in the winter than is necessary for summer cooling or utilize some other heat sources such as solar heat to balance bin size with cooling load. Solar energy in abundance is available in the early and late part of the heating season such as September, October, November, and March, April, and May. It is the months of December, January, and February, where over 50 percent of the heating requirements occur and solar energy is the least available, that the heat of fusion from ice becomes crucial.

In Atlanta the ACES equipment provides all heat and hot water, and 58 percent of the summer air conditioning. The remaining 42 percent of the summer air conditioning load can be shifted to nighttime operation to take advantage of better operating conditions and possible off-peak electric rates. Trying to apply ACES further south than Atlanta will depend on power cost differentials between winter and summer, with each location a separate study.

In Minneapolis at the northern end of ACES territory, the basic ACES equipment provides 100 percent of air conditioning requirements, 100 percent of hot water requirements, and 31 percent of heating requirements. It must be pointed out that the 31 percent of heating requirement that is furnished by freezing water is the portion of the space heating that solar panels could not furnish. Two hundred and fifty square feet of vertical solar wall or fence can be erected. These panels will receive 46,600,000 Btu/season or 186,400 Btu/ft². These panels provide 69 percent of the heat requirements when the heat received is elevated to heating temperature with the heat pump. Since it appears that the most efficient ACES package will include solar panels in the northern latitudes, a more complete study must be undertaken to determine the best cost-effective design and mode of operating the system.

Ice bin costs per unit volume decrease as the size of the bin goes up, which will tend to favor apartment, townhouse, and cluster housing which use a common bin as opposed to single family dwellings. The heat leakage into the bin per unit volume, which will cause melt-back go down as the size goes up. The diversity of service requirements also favors large systems.

The economic pay-back of ACES

The most thorough study was carried out for an existing apartment complex in the Washington, D.C., area. These 406 apartments are located in 68 different buildings, six apartments to the three-story building. They are heated and air conditioned from a central boiler plant fired with natural gas. The system is based on a two-pipe system furnishing 105°F water in the winter and 50°F water in the summer as well as 120°F domestic hot water all year around. We were able to obtain actual twelve-month usage records on the complex and analyze how an ACES and other conventional systems would have functioned during that same twelve-month period.

Figure 1 shows how the ACES ice storage bin was charged and discharged, with the actual heating and air conditioning, hot water load, and the estimated electrical load for the ACES equipment. Some 3059 kwhr of energy would be required per apartment-year for the heating, air conditioning, and hot water functions. Compared to the gas-fired apartments, ACES could possibly provide an energy saving of 71.2 percent, taking into account the generation and transmission losses of the utility in providing electricity to drive the ACES. Compared to all electric apartments, ACES could possibly save 77 percent of the energy required, or approximately 10,000 kwhr per apartment-year. The system breaks even at any cost of energy over 2.5¢/kwhr. In the Washington, D.C., area energy now costs 4¢/kwhr.

Typical extra cost for an ACES-equipped home when it is being built would be $1950 over the conventional electric furnace, airconditioner, and electric hot water heater. In retrofitting into an older home the cost would be between $3000 and $4000 depending on the home and its construction and previous heating system.

The most likely homes to be converted will be those that are now heated with oil or LPG and those that are now heated with electric resistance furnaces and/or baseboard. There are over 16 million of these homes located within the ACES territory according to 1970 U.S. Census. It can be seen that the ACES concept can have a profound effect on the energy consumption picture of the future.

To some extent it was frustrating to be a design engineer in the 1950's and 1960's when energy costs were often less than $1 per million Btu's. Thanks to the Arabs and higher energy prices we can now design energy efficient equipment that has a good return on investment and therefore can be economically justified.

The techniques for designing energy efficient equipment are well known. The patent files are full of ideas and methods (often long expired) which can be used to accomplish our goals of energy efficiency.

The idea covered in this paper dates back to 1957. Our years of manufacturing "cheap and dirty" systems has left this country a legacy of 75 million buildings that are obsolete from the standpoint of energy consumption. What a challenge this is for the engineering community, to insulate, modify, and equip these buildings to be efficient users of our remaining energy resources. This challenge may spark the biggest growth industry for the last quarter of the 20th century. pe

DEVELOPMENT OF INSTITUTIONAL MECHANISMS

Mr. YATES. On page 38, you refer to "developing institutional mechanisms to encourage homeowners to make the necessary investment to achieve maximum energy conservation."

Can you tell us what you have in mind? Give us an example.

Dr. MANNELLA. The life cycle costing demonstration.

Mr. YATES. How do you propose that thermal storage programs be applied to residences?

Dr. MANNELLA. ACES is an application of the thermal-storage technology.

Dr. SAVITZ. We would look at other media as the thermal-storage program develops, different masses of materials, either in the roofs or walls also.

PLASTER BOARD AND INSULATION

Mr. YATES. What are you going to do about plasterboards?

Dr. MANNELLA. In what sense?

Mr. YATES. In the sense of saving insulation. Every contemporary apartment building I have been in lately has plasterboard between buildings. That really doesn't help you with your insulation, does it? Don't you really need plaster in order to get the proper insulation?

Dr. SAVITZ. If there is space between, you can put the insulation behind it.

Dr. BELDING. We are going to have an awful lot of plasterboard with the fluidized beds. They use limestone which you then throw away, so you can make plasterboard.

Mr. YATES. You are not opposed to plasterboard then?

Dr. SAVITZ. No; if there is space to put it in. The problem is if you get something like an all masonry or all concrete building, when a person goes to try and live in that house and decorate it with wall coverings and things like that, it isn't appealing. You have to worry about the consumer preference.

Mr. YATES. What innovations in basic designs do you have? You are just working with the American Institute of Architects on that?

INNOVATIONS IN BASIC BUILDING DESIGN

Dr. MANNELLA. We are working with AIA, yes. The Minimum Energy Division in Mission Viejo is one example.

Mr. YATES. What are the innovations you are talking about?

Dr. SAVITZ. There can be others. Megastructures is a concept where you might have a large part of the facility in dirt, and then you flow the roof so that you can still make use of sunlight, but you don't have the normal type of construction, foundation, blocks for walls and windows. You have part underground and part aboveground.

Mr. YATES. It sounds like a bomb shelter.

Dr. SAVITZ. No; because you have the floating roof; you have got the Sun and it is something that has been applied in Japan in a pavilion that the United States has there, also looking at underground structures and curved structures, and other ways.

Mr. YATES. How about caves?

Dr. SAVITZ. Some of the people actually in the Southwest are looking at cave-type of things. A lot of this is nothing new. It is reinstituting things.

Mr. YATES. We have heard of several uses for the salt domes.

Dr. SAVITZ. I don't think you would want to live in those.

USE OF FOREIGN TECHNOLOGY

Mr. YATES. How much are we utilizing technology and information developed in this overall area by the Europeans and other foreign sources? We talked about the Japanese.

Dr. SAVITZ. We are working very close with Europeans in the International Energy Agency and also the NATO activities.

Mr. YATES. Are we all through with the old style building of a nice looking house on a hill overlooking a meadow?

Dr. SAVITZ. No; I think you can still build an attractive house that will overlook the meadow and have the right material in the window, maybe the side that is in the hill can be all——

Mr. YATES. In the hill.

Dr. SAVITZ [continuing]. Can be in the hill, or in back. If you design to the site rather than just repeat the same house here that you repeat in Arkansas that you repeat in the Northeast and the Northwest, I think——

INTEGRATED COMMUNITY ENERGY SYSTEMS

Mr. YATES. Would you place in the record an explanation of how ICES is to work?

Dr. MANNELLA. We will be happy to, Mr. Chairman.

[The information follows:]

THE COMMUNITY ENERGY UTILIZATION SUBPROGRAM

INTEGRATED COMMUNITY ENERGY SYSTEMS (ICES)

CONCEPT AND STATUS

CONCEPT

A. The need for Integrated Community Energy Systems

Events of recent years have created public demand at the community as well as the national level for energy supply systems that satisfy human needs and that are energy-conserving, safe, environmentally acceptable, reliable and "price stable" -- that is, consumers can expect that their energy expenditures will be a relatively constant share of their total budgets. The Integrated Community Energy Systems (ICES) Program of the ERDA Office of Energy Conservation is designed to develop community-scale energy systems with these characteristics. These systems will represent an integration of community design, energy energy planning and energy technologies, all tempered by the commercialization aspects as defined from efforts to mobilize the private sector for adoption of this concept.

B. A Definition of "Community"

The definition of "community" as used in the phrase "Integrated Community Energy Systems" is: a complex of facilities (and open spaces) that are employed in human activities and that are connected by networks for moving people, messages, goods and services in the residential, commercial, industrial, agricultural, recreational or institutional sector. The "networks" may be transportation routes or modes, pipelines, communications links, telephone or electrical transmission lines, etc. Superimposed on the physical landscape of any community are complex political, social and economic systems, and jurisdictions that determine the types and levels of the community's activities. Thus, a "community" may be as diverse as a municipal or suburban business district, a farm community, or a multi-zoned Planned Unit Development, to name only a few. Furthermore, the ICES Program is conceived for communities in various stages of development and for in both new and redeveloped areas.

C. Integrated Community Energy Systems and Their Role in Communities

An integrated community energy system is more than a new hardware system -- although equipment certainly is a part of an ICES. Neither can the concept be limited to urban design of buildings or arranging activities in space. An integrated community energy system will not necessarily supply only a single service, e.g., electricity, in an energy-conserving fashion, such as by recovering waste heat from the energy system. Rather, the whole ICES ... concept seeks an optimal combination of all dimensions to meet the energy requirements of a particular community. An ICES is an investment in integrated human, building, network and hardware systems that becomes an integral part of the larger community. These systems will provide energy-using services to support the residents' lifestyles in a stable and environmentally sound fashion. One may simply refer to the concept as the integration of energy requirements, the sciences of human settlements (Ekistics), environmental considerations and economics. This integration is referred to

as the "4-E's" (Energy, Ekistics, Environment and Economics).

The approach is to utilize alternative energy resources and select a combination of technologies, community design and governmental arrangement that will provide a highly efficient, integrated community energy system. The hardware may include the following elements: an electric-power-generation option; the use of all forms of wastes including refuse, sewage, industrial and wood wastes, agricultural and biomass, whether or not purposely cultivated and harvested; solar space heating and cooling; solar hot-water heating; solar process-steam production for industrial and commercial use; and the use and conversion of coal to gaseous or liquid fuels. From an energy-conservation viewpoint, the recovery of waste heat from all varieties of thermal processes must be included. One seeks to couple elements of the above so as to obtain synergistic effects among them to enhance efficiency, economics and the environment.

The design of a building complex or an entire urban community will be closely associated with human productivity and energy consumption. If the density of buildings and residences is quite diffuse, then the need arises for unproductive time and energy consuming activities for communication or the delivery of goods and services. The over- and under-utilization of a facility will likewise be wasteful and unproductive, and often environmentally unacceptable to the community residents. Restructuring or regrouping of human activities and complexes which will enhance habitability will tend to increase productivity and can decrease energy budgets. Thus, the manner in which a community has chronologically evolved should be carefully scrutinized since it is likely that there exist many opportunities for enhancing habitability, productivity and energy savings.

STATUS

Activities in the subprogram area has been subdivided into three categories: Integrated Systems, Community Design and Commercialization. These activities, although separate in specific definition and direction, are continuously interfaced and provide input to each other. Therefore the status of ICES can be best provided by giving the status of the three categories of the Community Energy Utilization Subprogram; Integrated Systems, Community Design and Commercialization.

A. Integrated Systems

Two very important concepts of new ICES demonstrations - the Grid Connected ICES and the Coal Using ICES - are well underway towards initial operation in FY 1981 and 1982. The Grid Connected ICES concept based on experience gained through the feasibility analysis in Pasadena, California during FY 1976 and five more sites in FY 1977, is now in the detailed design stage. The Coal Using ICES concept using the analysis and design tools developed through the Systems Engineering effort is being applied at Georgetown University in downtown Washington, D.C.

The demonstration program for other concepts such as the Heat Pump Centered ICES, District Heating and Cooling and Power Plant Retrofit to ICES will be initiated in FY 1978. All demonstration programs are relying heavily on analysis and design tools developed and under development in the Systems Engineering activity. The Systems Engineering started in FY 1976 with planning and organization and has initiated a technology evaluation for ICES, a simulation program for application and a systems development for advanced concepts. These activities will continue in FY 1978 with emerging technology evaluations, development of a complete simulation tool for analysis and the development of several concepts for advanced ICES. All these tools and evaluations are expected to support and enhance the demonstration activities.

B. Community Design

The initial priorities of the Community Design activities have been the systematic development of both a quantitative understanding of the relationship between end use energy consumption and the physical characteristics of the community. More specifically this work has involved collection and analysis of relevant data to determine the importance of non-technological factors, more energy efficient community design concepts and a process or methodology whereby energy conservation considerations could be incorporated into the community development process and assessed against financial, social and environmental considerations.

Extensive progress has been made in the development of the Ekistic Energy Community Model. This model is designed to identify annual end use energy profiles by service demand (space heating, lighting, etc.) rather than by energy form (electricity, gas, oil). A study was completed that developed planning guidelines for energy conservation for the proposed new State Capitol City in Alaska. A method was established for development of energy flows and ranking alternative options based on energy-economic scenarios developed from the energy flows. An Agreement has been made with the Greek Government for joint activities involving studies of human settlements and energy. The development of energy master plans has been initiated and energy planning for small communities and towns was evaluated. Two cities were used to evaluate energy planning as now practiced by the profession. These activities showed the grave need for development of additional tools to assist in this profession.

C. Commercialization

It is the objective of the commercialization area to provide the data and the development (through RD&D) of a strategy which can enhance the adoption of energy conserving community designs and systems that satisfy the energy needs of a community. This is to be accomplished by providing to local decision makers, information about options which have been proven through the RD&D effort and which will assist those segments of society concerned with the procedure to modify traditional practices established during the era of low cost, non-limited energy.

Studies have been made to quantify the potential market shares for ICES. This data was inputed to the Integrated System and Community Design area to allow for prioritization of activities. Impediments to widespread commercialization of ICES were identified. The most severe impediments were grouped under two major headings of "Legal and Regulatory Issues" and "Establishing a Lead Authority". It was determined that under the existing structure, private business men and investor owned utilities have little, if any, incentive to practice energy conservation, other than their sense of responsibility.

Case studies were made of existing systems that now operate very similarly to ICES to draw upon those experiences in development of options for the future. An analysis was made of a military community (Sewell's Point Naval Complex) to identify what savings may be achieved when institutional barriers are basically eliminated. A State Energy Office was provided with funds to test a new technique of utilizing a voluntary task force of individuals from local government and private industry working together to define problems and recomment solutions for energy conservation using the ICES concept.

INTEGRATED COMMUNITY ENERGY SYSTEMS

Mr. YATES. Have you received or are you contemplating specific sites for demonstrations?

Dr. SAVITZ. Yes.

Dr. MANNELLA. The first five phase won awards which we will narrow down as we get into the actual demonstration.

Mr. YATES. What specific sites? Give me an example.

Dr. SAVITZ. One is a redevelopment area in Trenton, N.J. Another is a hospital complex in Louisiana.

Dr. MANNELLA. Clark University in Worcester, Mass.

Mr. YATES. What kind of energy savings are you talking about?

Dr. SAVITZ. We are talking about overall combining the waste heat use from the power generation which is normally 30 percent efficient, and your heating which may be just 50 percent efficient. We are talking about possible 70 percent efficiency for space conditioning and the electricity.

ADVANCED TECHNOLOGY MIX ENERGY SYSTEMS

Mr. YATES. Now we have the advanced technology mix energy systems.

Will you put an explanation in the record of how that relates to the ICES program?

Dr. MANNELLA. We will be happy to.

Mr. YATES. With some examples.

[The information follows:]

THE COMMUNITY ENERGY UTILIZATION SUBPROGRAM

INTEGRATED COMMUNITY ENERGY SYSTEMS

ICES SYSTEMS ENGINEERING (ATMES)

The Concept of Integrated Community Energy Systems (ICES) employs the systematic interactions of energy systems, community design and commercialization activities that will allow for meaningful implementation. The Program therefore has been subdivided into three areas: Integrated Systems, Community Design and Commercialization.

The Advanced Technology-Mix Energy Systems (ATMES) program is under the subarea of Integrated Systems. It is designed to apply mixes of current and emerging energy technologies, energy and waste management techniques to the total ICES area.

The phrase "advanced technology-mix" implies the novel synthesis of existing, emerging and future technologies into integrated energy systems and subsystems. Such systems in general entail the combining of lighting, climate control, hot water and possibly solid and liquid waste services -- with the objective of conserving energy.

The role of ATMES in the overall Community Systems Program is the identification and evaluation of concepts. Thus activities such as technology evaluations, development of methods for simulation and optimization of ICES, systems development, evaluations of advanced ICES, and testing of components and subsystems for integration into ICES are within the scope of ATMES. When an ICES concept is sufficiently promising to warrant a large scale pilot or demonstration (i.e. the concept has successfully emerged from the ATMES evaluation process), then that concept is pursued via a separate line item.

If one expands the role of ATMES slightly to provide engineering support to ICES demonstrations, then one has achieved the full dimensions of the ICES Systems Engineering Program. Therefore, ATMES has given support in the form of ICES Systems Engineering with the following objectives:

(1) Develop basic data and methods for evaluation and design of ICES (e.g. technology evaluations, simulation/optimization design methods and design manuals)

(2) Identify and conduct preliminary engineering and economic evaluations and intercomparisons of numerous ICES concepts (leading to an ICES Systems Guide)

(3) Conduct detailed engineering evaluations of advanced ICES concepts

(4) Perform tests of components and subsystems for integration into ICES (at NASA's MIST facility and possibly at a new comprehensive Community Systems Test Facility)

(5) Provide engineering support to ICES demonstrations, especially in the feasibility and design phases.

COAL USING SYSTEM

How does the coal using program differ from the ATMES program?

Dr. MANNELLA. The coal using system would perhaps be one example, what you would do under the ATMES program. The ATMES program is essentially sort of a technology base, a screening technique, to determine whether or not some proposed technology like a coal using system fits into the requirements of the community energy system. This particular study is connected with the work that Fossil Energy is doing at Georgetown University with their fluidized bed combustor.

DISTRICT HEATING

Mr. YATES. Isn't there a great deal of technology already available on district heating in Europe?

Dr. SAVITZ. That is what we are working on and we are trying to adapt their codes and their conditions to the United States.

Mr. YATES. There is where?

Dr. SAVITZ. It is a joint project with Sweden. We are putting up money and they are putting up money.

Mr. YATES. They have an advanced technology.

Dr. SAVITZ. Yes.

Mr. YATES. What about the Germans and the French and the British?

Dr. SAVITZ. They also. The Swedish have been the most advanced.

Mr. YATES. Innovative.

Dr. SAVITZ. In this area.

Dr. MANNELLA. They tend to locate their——

Mr. YATES. Do they use Danish modern and Swedish innovation?

Dr. MANNELLA. I am not sure.

POWERPLANT RETROFIT

Mr. YATES. That wouldn't be an innovation though, would it? What is your powerplant retrofit program going to do? That is a good one, isn't it?

Dr. MANNELLA. In a sense it is part of our waste heat program, to try to see if we can use the waste heat from powerplants or optimize the operation of the powerplant in such a way that it is possible to use the waste heat for community applications. We have, for example, right here in the District of Columbia a powerplant, I think it is Pepco No. 1, that is a good example of a plant that wastes its waste heat.

Mr. YATES. So what are you going to do about it?

Dr. MANNELLA. See what possible applications you can make of it on a community basis.

Mr. YATES. Are you giving them any money to do this?

Dr. MANNELLA. I am not necessarily saying that we are looking at Pepco No. 1.

Mr. YATES. You are not doing it with Pepco.

Who are you doing it with?

Dr. SAVITZ. We are doing it in Burlington, Vt., with the utility company there. They have a capacity that is not very efficient that

is older but they are not planning to build a new one. They are connecting it with a university complex there and seeing about making use of the waste heat from that powerplant which is located down the road to provide some space conditioning for the university.

Mr. YATES. How much will that cost?

Dr. SAVITZ. We are just paying the overcost and looking at the monitoring and the institutional——

Mr. YATES. What other utilities did you recommend?

Dr. SAVITZ. That is the only one we are looking at for that specific one, but we are in other programs working with Minnesota Power, working with California Gas, working with New England Power Co.

Mr. YATES. Do you work with FPC on the question of more efficient use of public utility electric systems?

Dr. SAVITZ. We are not involved with the rates; no. We are trying to make use of the waste heat as a source to supply heating for buildings.

Mr. YATES. What is the potential saving on your retrofit for powerplants? Enormous, isn't it?

Dr. SAVITZ. Yes; because there are lots of things when you consider the electricity.

Mr. YATES. Lots of them all around. I suppose the public utilities don't use much waste heat because they pass whatever cost they have on to the consumers, and there is no incentive really for them to use their waste heat?

Dr. MANNELLA. That is part of the problem. The other part of the problem is that there are relatively few opportunities because they are generally not cited favorably for utilization of the waste heat and they don't like to get into say the chemical business by building a chemical plant next door to their utility which would use the waste heat.

Mr. YATES. Why wouldn't a chemical company come in there?

Dr. MANNELLA. It is conceivable if the energy supply problem was severe enough that they would co-locate, but the utilities do no aggressively pursue options.

Dr. SAVITZ. They do not want to get in the building business.

GRID-CONNECTED TOTAL ENERGY SYSTEMS

Mr. YATES. You are still interested in the grid-connected system like the one in Pasadena. Why?

Dr. SAVITZ. Because it looks like there is a lot of potential where you are talking about small generating plants being sized for shopping centers, hospital complexes, school complexes, and really increasing the efficiency by feeding it directly into the grid.

Mr. YATES. Why did the Pasadena fail?

Dr. SAVITZ. Pasadena failed because the climate in Southern California didn't lend to a large heating season, and in the original proposal they were going to have 6 million square feet of space and in that sense the economics would have been there, but we found out that the amount of money they could raise would lead to about 1 million square feet, so it is a matter of appropriate size and climate in order to make it economical.

COMMUNITY ENERGY UTILIZATION PROJECTS

Mr. YATES. You have a description starting on page 45 of end-use conservation and technologies to improve efficiency; land use and energy, urban laboratories, community subsystems evaluation, comprehensive community planning, and commercialization.

How effective are all your efforts in these projects? Are they effective?

Dr. MANNELLA. Many of these are new. We will be starting them really for the first time either this year or next year.

Mr. YATES. How about those that aren't new? Is it too early to give an appraisal of them?

Dr. MANNELLA. That is right.

Mr. YATES. How do you propose to gain the cooperation of communities under your community planning project?

Dr. MANNELLA. Working with the various city and regional planning organizations, urban redevelopment organizations that exist within the communities.

Actually we have been approached by any number of communities that are interested in whether or not we would support some aspect of their planning requirements as it relates to energy. We don't think we will have any problem in getting good response to our PON's in this area.

Mr. YATES. Any problems with communities so far?

Dr. MANNELLA. Not so far, but it is still very early in the game.

Mr. YATES. I would like to be advised on this. Would you explain in the record what the Community Subsystems Evaluation, Telecommunications does?

[The information follows:]

COMMUNITY ENERGY UTILIZATION SUBPROGRAM—COMMUNITY SUBSYSTEMS EVALUATION, TELECOMMUNICATIONS

The community design activities within the subprogram are all related with the development and demonstration of concepts that will assist in energy optimization through the orderly arrangement of activities and functions of a community. One major consideration in community design is the need for networks to connect the individuals, facilities, and functions that must be joined in the daily intercourse. Telecommunications, as now employed in a community, does not appear to have a significant impact on energy use. However, with proper integration into the community life style it may significantly impact energy use.

This activity within community design will provide the means by which assessment will be made of the utilization of telecommunication as an energy conserving mechanism. This effort was initiated with an interagency agreement between ERDA and DOC in 1976 for the joint funding and participation in the Interagency Committee on Telecommunications Applications. It is expected to incorporate advances in telecommunications into the community design program by evaluation of different subsystems or components to determine the energy impact on communities through demonstration by cost sharing where possible. It is expected that these demonstrations will allow the overall community design subarea to give proper attention and make full utilization of new developments in telecommunications technology in the overall community energy planning.

MARKET ANALYSIS/MARKET SHARE OBJECTIVES

Mr. YATES. You talk about the market analysis/market share objectives with regard to the private sector adoption of community systems. What is the private sector attitude toward these systems?

Dr. SAVITZ. In general utilities have been negative about some of these systems because particularly in something like smaller grid-connected systems they want to supply electricity and don't want to be in the position of just being there for balancing loads of the community. Part of the reason for doing the demonstration is to get utility, and one of our stipulations is utility has to be involved to show that it can be beneficial for them to be involved.

Mr. YATES. But the private sector adoption of community systems relates to other aspects of the community.

Dr. SAVITZ. Private developers are also involved. They may be an additional first cost in putting in the collection for waste heat.

Mr. YATES. What is done in the man/systems optimization area? What is the amount of funding?

Dr. SAVITZ. That is $100,000, and that is looking at the manpower requirements that would be involved and the training requirements for operating and maintaining the system.

URBAN WASTE

Mr. YATES. Let's turn to urban waste.

What is the estimated energy substitution for oil and gas by urban waste systems?

Dr. MANNELLA. By 1985 we think there is potential for half a million barrels of oil per day equivalent savings.

POMPANO BEACH PROJECT

Mr. YATES. Is the Pompano Beach project one of yours?

Dr. MANNELLA. Yes.

Mr. YATES. What is its status?

Dr. MANNELLA. We broke ground for that several months ago. It should be processing waste and creating off-gas for analysis by the end of this calendar year.

Mr. YATES. Is there cost sharing?

Dr. MANNELLA. Yes; it is, Waste Management, Inc.

Mr. YATES. On what basis?

Dr. MANNELLA. I will have to give you the exact figures. I may have it here. We can perhaps provide it for the record.

[The information follows:]

COST SHARING AT POMPANO BEACH PROJECT

No cost sharing was required by the original competitive proposal and the contractor offered none. However, the contractor has offered and is supplying certain items that would be expenses to the project if an independent site were selected. These are:

(*a*) The contractor is furnishing 1.3 acres of land without cost to the project. He is now considering acquisition of a nearby parcel of the same size at a price of approximately $17,000. The contractor is also paying all real estate and other associated taxes on the property.

(*b*) The contractor is furnishing waste shredded to a nominal 6-inch size without cost to the project. The cost of shredder building and ancillaries required to achieve receipt and this degree of size reduction is estimated to be $7 per ton considering capital and operating and maintenance costs. Note that the contractor incurs this expense whether the ERDA plant operates or not; however, if located independently, this could be cost to the project. The project will use 50 to 100 tons of waste per day or $125,000 to $250,000 of waste per year.

(c) The contractor is disposing of sludge filter cake without cost to the project. The value of disposal is estimated at $10 per wet ton. The estimated wet filter cake to go to the landfill is 3.5 tons per hour which represents a disposal cost of $300,000 per year.

(d) The contractor is sharing maintenance personnel with the ERDA test site. Thereby an estimated 2¼ man-years (½ site superintendent, ½ time of electrician, ½ time of mechanic, and ¾ time of a welder) will be saved at an estimated cost of $40,000.

(e) The contractor is performing some sludge disposal experiments at his expense and initiative.

SEATTLE MUNICIPAL WASTE PROJECT

Mr. YATES. Will you be providing price supports to the ammonia generated in Seattle, Wash., by the waste process?

Dr. MANNELLA. This really has not been decided. We are mostly in the role of advising the Seattle people. We have no provision for price supports.

ERDA ROLE IN MUNICIPAL SOLID WASTE PLANTS

Mr. YATES. What are the economics of municipal waste plants? Are you building any? Are you expanding any? Are you subsidizing any?

Dr. MANNELLA. Our role is rather narrowly defined relative to EPA which has the responsibilities for the entire solid waste area. We are concentrating on those types of projects that relate to energy in urban waste and it boils down to several kinds of technologies and conversion processes, and basically what we are interested in is one-of-a-kind demonstrations in a real environment to get operating data and economic data and then would look for the municipalities to either do this on their own or do it with EPA through the Solid Waste Recovery Act, and other institutions.

ALTERNATIVE FUELS PROGRAM

Mr. YATES. Do you have a tentative amount set aside in the $300 million for alternative fuels for which you have not forwarded any legislation yet?

Dr. MANNELLA. For alternative fuels?

Mr. YATES. Yes.

Dr. MANNELLA. For transportation vehicles?

Mr. YATES. No; under the Biomass loan guarantee, under the urban waste.

Dr. MANNELLA. No.

EUROPEAN MUNICIPAL WASTE TECHNOLOGY

Mr. YATES. All right. Is there any European technology being used in this connection?

Dr. SAVITZ. In this country there are some. Waterwall incinerators are being used, by an outfit in Lynn, Mass.

TECHNOLOGY AND CONSUMER PRODUCTS

Mr. YATES. Will you put a list in the record showing the budget authority for each project under Technology and Consumer Products, the amount of industrial cofunding, and the potential energy savings? Also, what ideas you are pursuing for integrated appliances.

Dr. MANNELLA. Be happy to.
[The information follows:]

INTEGRATED APPLIANCE PROJECT

This project, contracted to A. D. Little, Inc., focuses on residential and commercial appliances, which together, including space conditioning, account for about one-third of U.S. energy consumption. The principal guide for the integrated appliance project is that heat rejected by one appliance can be used to operate another (for example, heat rejection by refrigeration systems can be used to heat water).

The first phase of the project is designed to select one or more combinations of appliances which have been identified by a comprehensive evaluation to be the best candidate(s) for a practical combined unit and to plan a development and demonstration plan to be accomplished in a second phase of the project.

The hundreds of possible combinations of appliances were reduced by a three-stage screening process to the three best choices. Detailed analyses and formulation of development and demonstration plans are currently being performed in concert with an appropriate manufacturer who will share the costs of the development and demonstration. The three candidates chosen for detailed analyses are an integrated residential gas furnace-water heater, a residential unit using the waste heat from a residential air conditioner for water heating, and a commercial unit utilizing the waste heat from a range hood.

Development and demonstration of the selected candidate(s) are to be initiated based on the plans which are scheduled to be completed by mid-1977.

Some barriers to commercialization of integrated appliances are convincing the buyers and users that the units are cost-effective and reliable. Others are matching the life of the units and matching the supply of waste energy from the donor appliance to the demand of the other appliance. Other barriers occur because these kinds of units are not addressed by present test procedures, labels, and standards for both performance and safety. Thus, these must be developed and accepted to achieve commercialization of these products.

INSTITUTIONAL BARRIERS TO INTEGRATED APPLIANCES

Mr. YATES. What are the institutional barriers to which you refer and how do you intend to cope with them? Are there institutional barriers to the question of integrated appliances?

Dr. SAVITZ. We have been talking to appliance manufacturers. There has been some barrier since there may not be a large enough market just in the mobile home industry for it to be a viable commercial product and it can be more expensive to make, so it is the first cost aspect.

Mr. YATES. What is meant by an integrated appliance?

Dr. SAVITZ. That is where you take the waste heat, let's say of a refrigerator and use it to preheat water. In mobile homes it is something that could be built in when the homes are manufactured and you can place the appliances one next to the other; for example, waste heat from the clothes drier can be used.

Mr. YATES. What are you doing to cope with industry objections?

Dr. SAVITZ. Our first thing that we are doing is studying what are the best potentials for integrated appliances, what combinations make sense, looking at the economics, and then trying to see if we can interest mobile home manufacturers to work it out from that end, so then they in turn encourage its usage.

ERDA AND FEA APPLIANCE PROGRAMS

Mr. YATES. How do you correlate your appliance program with FEA?

Dr. SAVITZ. FEA is essentially developing test procedure for labeling and also standards for existing technology, and our program is looking at new technology which may or may not be available by the 1980 time frame, so we work closely with them.

Mr. YATES. If FEA is establishing standards for appliances why does ERDA have to fund them? Won't industry itself do it?

Dr. SAVITZ. They are being set for 1980, and we are looking down the road as you get into the 1980's what are the technological potentials and the economics involved.

GAS-FIRED HEAT PUMPS

Mr. YATES. What is the potential of your gas-fired heat pump program?

Dr. SAVITZ. Essentially if you look at a furnace as being 65 percent efficient at delivering heat from the gas to the home, you can get twice the amount of heat delivered out of the same unit of gas because it is extracting both heat from the air and also heat from the waste stream.

ENERGY MANAGEMENT IN BUILDINGS AND BUILDING SYSTEMS CONTROLS

Mr. YATES. Would you place in the record an explanation of the devices that are going to be demonstrated in your energy management in buildings and building system controls?

Dr. MANNELLA. Be happy to.

[The information follows:]

Buildings Energy Management/Controls Program

Program Objectives:

1) Identify, evaluate, and disseminate information regarding energy conservation in buildings through improved control and management of heating, ventilating, and air conditioning (HVAC) and lighting equipment.
2) Assist industry in developing, demonstrating, and commercializing new and better building control devices which have the potential for large energy savings when it is appropriate for government assistance.

Program Approach:

Initiate projects investigate, develop, and demonstrate those control strategies and systems which have a potential for large energy savings, yet have either high financial or technological risks to the industry.

Occupancy Detector Based Control Systems for Energy Conservation in Buildings:

This project will demonstrate the potential energy savings related to controlling the amount of outside ventilation air allowed into a building based on detecting in real time the number of occupants within the building. This will result in the reduction of the heating and cooling loads in the building. The demonstration of hardware will be confined to retail stores in the Boston, Massachusetts area, however an in depth analysis will also be performed on the use of this technique in various types of buildings in various climatic regions.

Automated Energy Management Systems for Small Buildings:

Evaluate the potential of automated energy management systems for saving energy in small to medium-sized buildings. Evaluations will be based on system capital costs vs. payback period. Cost-effective designs will be analyzed and, if effective, will be developed and demonstrated in a later phase.

Evaluation of Hotel/Motel Automated Control Systems:

Evaluate and demonstrate cost/effective control devices for automatically shutting off heating/cooling, lighting, etc., when hotel/motel rooms are not occupied.

Large amounts of energy are commonly wasted with continuous provision for space conditioning regardless of occupancy and need. Personal behavior of occupants accounts for wasted energy after their departure. There are technical opportunities for installing simple and cost/effective control devices and systems which would automatically shut off energy services to rooms not occupied. A demonstration is being conducted in cooperation with the American Hotel and Motel Association using commercially available control devices to evaluate energy savings under practical conditions. Results of the demonstration are to be disseminated to hotel and motel managers.

Analysis and Evaluation of a Microprocessor Based Thermostat:

Evaluate the concept of a microprocessor based thermostat capable of responding to rates of temperature change in buildings. This offers the possibility of introducing an inexpensive microprocessor system into the residence which could be expanded into more complex automated control.

LITEK LIGHT BULB

Mr. YATES. We are not ready to commercialize the screw-in fluorescent bulb, are we?

Dr. MANNELLA. That is correct.

INFRARED THERMOGRAPHY

Mr. YATES. What is ERDA doing in infrared thermography R. & D?

Dr. MANNELLA. We have a joint program with the Energy Office of Minnesota, and essentially what it consists of is fly over of homes in an airplane equipped with an infrared scanner which then results in a film record. Individual homeowners can then be shown and can detect either the degree of insulation or the heat leakage in their building. In this experiment those homeowners that have gone back and corrected the situation saw a lot of heat leakage to the roof and consequently have insulated the roof. The second fly over has shown the results of that corrective action, and it seems to create a very nice response in the community, and might be a very good way to motivate people to plug up some of the heat leaks in the private residences.

INDUSTRY EFFORTS TO IMPROVE GAS-FIRED FURNACES

Mr. YATES. Is industry doing anything toward developing improved gas-fired furnaces and oil burners?

Dr. MANNELLA. Yes; there are some developments going on in this area, and the role that we are playing here primarily is to create a testing facility at the Brookhaven National Laboratory where we can test these and determine the efficiency under standard set of conditions.

Mr. YATES. What is a heat pipe?

Dr. MANNELLA. It is a heat conductivity device, just a way of conducting heat from one spot to another spot.

CONSUMER MOTIVATION AND BEHAVIOR

Mr. YATES. Would you place in the record an explanation of how you intend to motivate consumers, to use your phrase?

Dr. MANNELLA. Be happy to.

[The information follows:]

Consumer Motivation and Behavior Projects

The objective of the consumer motivation and behavior program is to conduct research on ways to work with the private sector to encourage consumers to (1) purchase and use more energy efficient products and (2) adopt and maintain more energy efficient practices. While the primary thrust of the Division of Buildings and Community Systems, has been on developing more energy efficient technologies, it has become increasingly apparent that motivating the consuming public, whether commercial or retail, to make use of more energy efficient technologies is as important and difficult a challenge as developing these technologies. Barriers to more efficient use of energy by consumers range from lack of credible information on possible savings and difficulty of obtaining convenient financing for more expensive products, to aversion to higher first cost.

The overall strategy is to identify approaches to overcoming these nontechnological barriers and to conduct research and testing in a controlled manner to see if they have the potential for significant energy savings and successful research is conducted in close cooperation with private sector organization, such as retail merchants or utilities, which would be the ultimate implementors. If the preliminary testing indicates that the approach has merit, a demonstration and evaluation is conducted jointly with the private sector group. Many of these approaches have not been associated with Federal programs in the past, such as working with retail merchants (e.g., Sears, Montgomery Ward) to encourage purchase of energy efficient products by consumers in a manner which is beneficial both to the retail merchants and to the achievement of significant energy savings.

Projects conducted support and will help to assure that technology developed as part of the BCS program achieves the energy savings projected. In addition, significant additional savings will accrue to the Nation if the approaches which are being developed to encourage more efficient energy practices by consumers are successful.

Explanation of Specific Projects

Strategies for Master Metered Buildings - Significant amounts of energy are wasted by occupants of master metered apartment buildings who do not pay their own utility bills. In some cases where individual meters have been installed in previously mastered apartment buildings, an average reduction in electricity use of 30-35 percent has occurred. Since it is not always possible or cost-effective to refit master metered buildings with individual meters, tests were conducted in FY 77 of several motivational strategies such as (1) social, using group decisionmaking and feedback, and (2) economic, where savings are divided among occupants and owners. In FY 78, building owners/managers in a selected city will participate in a demonstration of the most effective combination of strategies which were developed in FY 77.

Low Income Housing: Behavioral Strategies to Assist Residents in Reducing Reducing Consumption - In FY 77, in cooperation with the U.S. Department of Housing and Urban Development, an educational/motivational approach to energy conservation, tailored for residents of public housing projects were tested and refined in two housing authorities. This approach consists of simple educational materials, group meetings and regular feedback about progress. Resident and management reception has been enthusiastic. In FY 78, this approach will be documented or "packaged" so that it can be readily implemented by other interested housing authorities.

Marketing Strategies - Consumer lack of awareness and use of life cycle cost in purchasing energy consuming products is a significant barrier to the introduction and acceptance of energy efficient technologies, since many if not most energy efficient products have a higher initial cost. There will be significant duplication of resources if each energy efficient product which is introduced has to "resell" life cycle cost in order to achieve market penetration. In FY 77, a project was initiated in Denver, Colorado, to address the problem of how to motivate relatively unsophisticated consumers and bulk buyers to purchase higher first cost energy efficient technologies. This project, "Energy Cost of Ownership", involves major retail merchants such as Sears and Montgomery Ward as important participants, as well as local hardware stores. In FY 78, the Denver demonstration will be evaluated, and if the approach appears to be successful in communicating the concept of energy cost of ownership homeowners in a manner which encourages consideration of this idea in purchasing a wide range of consumer products, the demonstration will be expanded into several more cities.

Motivation and Feedback - Studies conducted by Princeton University in FY 77 strongly indicated that providing homeowners with regular and intelligible feedback about how much electricity and/or gas they are using can reduce consumption by approximately 10 percent, for much the same reason that a dieter is assisted by a scale. In FY 78, tests will be made of several forms of "money meter", which will desplay energy use in dollars and cents, and is intended for use in a visible and convenient place in the home, such as the kitchen. This testing will be conducted in cooperation with a utility company. Several utilities have indicated considerable interest in the feedback approach.

Institutional Barriers and Opportunities - In FY 77, activities were initiated to identify and develop opportunities to work with utilities and financial institutions to encourage energy efficient purchases and practices by consumers. In FY 78, a demonstration of "financing energy efficiency" for buyers of resale homes will be demonstrated in cooperation with first mortgage lenders. This approach involves including the cost of the approved energy efficient products/improvements in the first mortgage without increasing the downpayment or the interest rate. In the utility area, detailed demonstration plans will be developed for the "utility ownership option", which involves the utility owning, installing and maintaining an energy efficient product such as a heatpump. This approach is intended to overcome several existing barriers to purchase of these products, such as high initial cost and concerns about reliability. The consumer would pay a monthly charge, much as the telephone company charges a monthly rate for the telephone.

LIFE-CYCLE COSTING

MR. YATES. What do you intend to use to acclimate consumers to life-long cycle costing? What is the life-cycle costing demonstration program? Will you place that in the record?

Mr. MANNELLA. Yes, sir.

[The information follows:]

LIFE-CYCLE COST CONCEPT

In simple terms, life-cycle cost means considering the cost of a product over its lifetime, including operating and maintenance costs. Consumer lack of awareness and use of life-cycle cost in purchasing energy consuming products is a significant barrier to the introduction and acceptance of energy efficient technologies, since many if not most energy efficient products have a higher initial cost. There will be significant duplication of resources if each energy efficient product which is introduced has to "resell" life-cycle cost in order to achieve market penetration. In fiscal year 1977, a project was initiated in Denver, Colo., to address the problem of how to motivate relatively unsophisticated consumers and bulk buyers to purchase higher first-cost energy efficient technologies. This project—energy cost of ownership—involves major retail merchants such as Sears and Montgomery Ward as important participants, as well as local hardware stores. In fiscal year 1978, the Denver demonstration will be evaluated, and if the approach appears to be successful in communicating the concept of energy cost of ownership to homeowners in a manner which encourages consideration of this idea in purchasing a wide range of consumer products, the demonstration will be expanded into several more cities.

A detailed program plan for energy cost of ownership is attached.

ENTIRE COST OF OWNERSHIP—A DEMONSTRATION PROGRAM IN DENVER, COLO.

Background

The Office of Conservation, Division of Building and Community Systems, has the responsibility of encouraging the developing of energy conserving products for the buildings sector. Some of these products are intended for use by the residential homeowner, and range from heat pumps to light bulbs. The success of these products in increasing the efficiency of energy use is critically dependent upon their market acceptance.

To date, the majority of the efforts of the Division have focused on technical product and system development. It is becoming more and more evident that motivating the consuming public, whether commercial or retail, is as important and difficult a challenge as developing the technologies. Many consumers apparently do not consider the entire cost of ownership in purchasing energy consuming products. This is a major barrier to acceptance of new energy efficient technologies since many of these products have higher first costs. The concept of entire cost of ownership (life-cycle costing) simply defined means a commonsense approach to buying. In the contemporary market, "lowest price" does not necessarily equal "lowest cost." To purchase on a life-cycle basis, the consumer must consider the complete cost, initial plus operating, over the lifetime of the investment.

The traditional marketing approach would condition consumers prior to introducing a new product. When people fail to buy energy conserving products, it is evident that we need to know why, and how strongly, consumers are resisting. With such information, strategies can be established to expedite new product introduction and acceptance.

Objective

To accelerate acceptance of energy efficient products by increasing consumers' awareness and use of entire cost of ownership.

Overview

In fiscal year 1977 a demonstration will be conducted in a pilot city to introduce entire cost of ownership to consumers using specific energy efficient products to define the concept. Retail merchants such as Sears Roebuck and Montgomery Wards will be involved as major participants along with hardware stores, lumber

yards, and financial institutions. Two contractors in the pilot city will be competitively selected—one to conduct the research and evaluation component, the other to develop and implement the necessary media and communications strategies.

ERDA will fund the umbrella entire cost of ownership advertising and the research and evaluation component while the private sector participants will pay for specific advertising. If the pilot demonstration is successful in introducing this concept, this program might be implemented in six cities in fiscal year 1978.

A. *Selection of Products.*—The demonstration will utilize high- and low-cost energy conserving products already introduced to the marketplace which appear to be experiencing acceptance difficulties, for example, automatic night set back thermostat. The criteria for product selection will include:

Currently commercially available.

Payback period of 0 to 5 years.

B. *Selection of City.*—Denver, Colorado, has been selected for the pilot demonstration to determine the optimal approach to working with a community Criteria for selecting Denver included:

Geographic isolation.

Medium-sized population representative of the Nation.

Major national retail merchants located throughout the city.

Business community in the past has demonstrated a sensitivity, and willingness to participate in similar programs.

State and local government has supported similar programs.

C. *Task Forces.* To expedite the acceptance and implementation of the program in Denver, community task forces will be developed. These action groups will be comprised of key civic and business leaders. The task forces will be utilized heavily to increase the local acceptability of the program, primarily through such actions as:

Host an initial meeting with the private sector to discuss the program.

Act as local liaison to explain program to community leaders when their support is needed.

Act as liaison with the public sector as necessary.

D. *Retail merchants.* Companies such as Sears Roebuck, Montgomery Wards, Target, chain hardware stores and independent lumber yards will play an important and integral role in the promotion. Responsibilities of the merchants will include:

Provide prominent floor space for the point of sale demonstration display.

Financial support the project with media and point of sale advertising dollars.

Provide inputs to the design of the campaign and point of sale display.

Maintain inventories of the energy consuming products.

E. *Savings & loan associations.*—First mortgage lenders will be asked to participate in the retail promotion using energy products as premiums. Additionally, certain S. & L.'s will be asked to sponsor a promotion emphasizing energy conservation in the home. Areas of involvement will include:

Establishment of point of sale displays in lobbies.

Advertising support.

Premium gifts of energy conserving products.

F. *Role of the market research firm.*—A market research firm in the Denver area will be competitively selected to provide research and evaluation support for the pilot. This firm will assess homeowners' understanding of, and use of, entire cost of ownership in purchasing energy consuming products prior to, during, and after implementation of the demonstration.

G. *Role of the advertising firm.*—An advertising firm in the Denver area will be competitively selected to assist in communicating the concept to the community. In addition to developing the central theme of the campaign, the firm will:

Develop specific advertising message.

Recommend and eventually purchase media space.

Coordinate with advertising firms of private sector participants.

Design ERDA energy displays and implement installation in participating retail outlets.

H. *Timetable of Events.*—

November–December 1976:

ERDA develops contacts and determines level of interest of merchants, financial institutions, local government in Denver.

ERDA prepares procurement information and commences request for proposals from market research firms in Denver area.

March–April 1977:
ERDA reviews proposals and selects research firm.
Request for proposals from advertising firms in the Denver area commences.
Initial reactions of consumers awareness and use of entire cost of ownership in purchasing energy consuming products.
April–May 1977:
Initial report from research firm received.
Advertising firm selected.
June–July 1977:
Report reviewed and evaluated.
Marketing strategies developed.
Advertising firm coordinates with other participants.
August–September 1977:
Media campaign implemented.
Advertising campaign begins.
September–December 1977:
Demonstration program takes place.

I. *Budget.*—Estimated ERDA budget for program:

Marketing research	$ 65,000
Advertising and promotion	$100,000
Total	$165,000

J. *Staffing requirements.*—Initially, the program will be staffed by the program manager with support coming at times from individuals in the Consumer Motivation and Behavior Branch (CMB) of buildings and community systems. The program manager will have the full responsibility of coordinating and managing the contractors as well as establishing, developing and maintaining contacts with private sector participants and community leaders in the pilot city. As the program expands, depending on the number of cities, staffing will increase accordingly.

PREPARED BY

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LITEK LIGHT BULB

Mr. YATES. What is the Litek bulb?
Dr. MANNELLA. That is the screw-in fluorescent bulb.
Mr. YATES. You already explained that.
Dr. MANNELLA. Yes.

ECONOMIC ANALYSIS AND TECHNOLOGY TRANSFER

Mr. YATES. You are going to put in the record budget authority figures for 1976, 1977, and 1978, right, for the exhibits on economic analysis and technology?
Dr. MANNELLA. For exhibits, yes, sir.
[The information follows:]

Economic Analysis and Technology Transfer

a. B/A Requirements

	FY 76	FY 77	FY 78
Publication and Exhibits	$ 200	$ 112	$ 400
Demonstrations and Seminar/Workshops	375	163	790
International Programs	100	50	200
Modeling	175	100	200
Develop Procedures for Project Evaluation and Determine Secondary Impact	200	200	610
Total	$1,050	$625	$2,200

b. Potential Savings

The objective of Systems Analysis and Technology Trahsfer is to assist in promoting the acceptance and use of more efficient use of energy. Analytical tools and technology transfer techniques are used to provide both the developer and user of new technologies the information needed to make more intelligent decisions concerning those technologies. These functions are in support of and help to assure that technology developed in the Buildings and Community Systems program are put to use to achieve the anticipated savings of the specific technologies. Therefore, no energy savings per se are identified with projects in the economic analysis and technology transfer. The increased tempo of operations within the Division of Buildings and Community Systems to transfer the results obtained in our research program to the consuming public. Also, the results of our past research is beginning to become available, thus, they need to obtain widespread dissemination.

c. Co-Funding

There is less co-funding in this area than others in the buildings program since publications and exhibits, demonstration programs and seminar/workshops, and the project evaluation and secondary impact studies are in direct support of the technologies being developed by the BCS subprogram. Where appropriate,

we seek out co-funding. For example, in FY 77, a home buyers guide book is being prepared jointly by HUD and ERDA. A lighting manual is a joint project between ERDA and the National Electrical Manufacturers Association (NEMA). For some exhibits, contractors prepare the display models and ERDA funds the transportation, maintenance, and exhibit hall requirements. In FY 1977, this was done for the minimum energy dwelling and fast food restaurant exhibits.

The International program element is to initiate cooperative international efforts and develop international research and development agreements. A great deal of co-funding occurs in these projects. Examples include:

(1) Wiehl-Esslinger project

A bilateral U.S.-German project in which the U.S. is funding $250,000 and the Federal Republic of Germany $5,000,000 to study central heat pump study.

(2) Ekistic Community System Project

A bilateral U.S.-Greek project in which the U.S. is funding $150,000 and Greece $50,000.

(3) Energy Cascading Project

A project in which 7 countries are jointly funding a $500,000 project.

For our demand modeling effort in FY 78, there will be major co-funding occurring with the BCS Divisions funding $200,000, the Office of Conservation Planning and Policy funding $200,000 and the Federal Energy Administration funding $250,000.

We also have major projects relating to secondary impact studies of energy conservation technologies. Co-funding of these project are occurring with the Office of the Assistant Administrator for Environment and Safety.

Mr. YATES. What demonstration programs are you funding in this area? Do you want to put that in the record?

Dr. MANNELLA. Be happy to.

Mr. YATES. Will you also put in assessment of their effectiveness in the record?

[The information follows:]

Demonstration Programs in Economic Anslysis and Technology Transfer and their effectiveness.

There are four demonstration programs currently underway. One is with the League of Women Voters Educational Fund who will be working with four local chapters of the League to disseminate information on new consumer technologies and new techniques for conserving energy. The second is the Product Planning Team or "New Product Management Team", a small and diversified group of private sector executives experienced in the planning and commercialization of new products. The Team includes: two retired vice presidents of research, one of a major chemical company and the other of a major petroleum company; a patent lawyer; a bank executive; and a marketing executive of a utility company. The Team is already working with the program manager of the Thermally Activated Heat Pump. The other project has not been selected but the Milk Sterilization Program is being jointly evaluated by the Team and ERDA as a candidate project. The Team will provide to the ERDA program manager, the type of expertise available to a comparable program manager in private industry. Further, since they have stature in the private sector, they will provide assurance to private industry that the ERDA programs have been guided by the advice of experts in new product management. The third demonstration program underway is to test the Urban Technology System as a means of expediting the use of energy efficient technologies by municipal governments. The Urban Technology System is managed by Public Technology, Inc., a nonprofit organization, organized by the major local government public interest groups and under contract to the Research Applied to National Needs program of the National Science Foundation. The basic role of the Public Technology, Inc./Urban Technology System program is to act on behalf of cities, countries and states in applying technology to public problems and they focus on specific problems that have been defined as high priority needs by local government officials. The ERDA program will emphasis and focus on the energy efficiency aspect of the total Urban Technology System program. Energy technology needs of local governments will be developed and matched with ERDA sponsored technologies to determine matches and areas where ERDA should develop programs. Further, it is planned to establish a cooperative demonstration program to permit the Urban Technology System to participate in the implementation and use of one of the new technologies through such a program, local government can be persuaded that the technology can work for local government entities. The fourth program, the energy advisory service programs at Texas A&M and New York Institute of Technology were initiated to test various technology transfer channels such as energy hot lines, energy management seminars, energy conservation short courses, energy audits, referral services, energy information centers, etc., for their effectiveness in reaching their target audiences. By performing these tasks, Texas A&M and New York Institute of Technology have provided ERDA with valuable experience in two areas. One is the design, implementation, evaluation, and monitoring an Energy Extension Service. The other is the mechanisms and problems associated with the collection and evaluation on data needed to measure the energy savings associated with specific extension activities such as audits, hot lines and seminars.

In each of these demonstration programs, an evaluative factor is a key component to test the effectiveness of that approach. In each case, the ongoing evaluation will determine the effectiveness of the program and permit the expansion or cancellation of the program based on results. Based on evaluation to date, these programs will continue in FY 1978. The Urban Technology System offers promise of being an extremely good channel of technical transfer and will be strongly emphasized in FY 1978. The Texas A&M and New York Institute of technology programs will be concluded at the end of the present contract.

CONSERVATION'S INTERNATIONAL ACTIVITIES

Mr. YATES. Also will you place in the record a description of what we get out of our international program. Tell me now, what do we get out of our international programs?

Dr. SAVITZ. We are doing one program with the West Germans where they are looking at a heat pump which is using the river system. It is a water/air heat pump to heat a complex of apartment buildings and in the $5 million German project we are providing $200,000 to get the data that we can use, and it will save us doing the same thing here, so it is a direct transfer.

Mr. YATES. That is one instance. Are there many other instances where this happens?

Dr. SAVITZ. This is happening. We have agreements in four different areas with the European countries and this is occurring in projects like our storage system and there are other projects like that.

Mr. YATES. Will you list those for the record and also tell the committee what about industry's innovations?

[The information follows:]

INTERNATIONAL PROGRAM ACTIVITIES

(Program plan for ERDA's participation in the IEA working party on energy conservation research and development) (ERDA 77-57)

The International Energy Agency (IEA) was formed in the aftermath of the 1973 oil embargo by the United States and other members of the Organization for Economic Cooperation and Development (OECD) interested in working cooperatively to ensure adequate future supplies of energy. The Energy Research and Development Administration (ERDA) is responsible for coordinating the U.S. involvement in IEA's energy conservation research and development (R.D. & D.), which is administered by the working party on energy conservation R. & D.

ERDA's overall research, development, and demonstration (R.D. & D.) program is designed to achieve the national policy and energy technology goals outlined in "A National Plan for Energy Research, Development, and Demonstration" (ERDA 76-1). Projects pursued under the auspices of IEA's working party on energy conservation R. & D. must not only contribute to the achievement of those goals, which recognize that such projects may be cosponsored by other nations and may be conducted outside the United States:

Transfer technology among nations.—Working party projects should encourage the mutual exchange of new and existing technology that will benefit member nations.

Serve foreign policy goals.—Working party projects should seek to increase the efficiency of energy use and its availability, and thus contribute to international economic and political stability.

Optimize U.S. R.D. & D. expenditures.—ERDA projects conducted within the working party should result in larger net benefits than would similar domestic R.D. & D. activities.

Promote the development of competitive U.S. industries.—Working party projects cosponsored by the United States should encourage the growth of U.S. industries able to compete successfully in international markets, thereby strengthening the U.S. trade position. The projects should also help open new foreign markets to U.S. industry.

The working party on conservation research and development has identified 11 project areas and decided to develop an implementing agreement for each. These agreements have been prepared and discussed by the experts groups in each area and are currently being reviewed and signed by member nations interested in becoming contracting parties. Annexes have also been written to cover specific projects in several of the 11 project areas.

Work is currently under way in the following areas:
Buildings and community systems,
Heat pumps,
Energy cascading,
Heat transfer,
Combustion,
Materials, and
Industrial processes.
Proposed projects are being considered in the following areas:
Energy storage,
Utilities,
Transportation, and
Energy recovery.
A copy of our program plan for international activities is attached.

UTILIZATION OF TECHNOLOGIES IN MORE THAN ONE INDUSTRY

Mr. YATES. Are you buying anything that industry has advanced in the field of energy so that you can test it or use it for other industries which may not have it? I suppose what I am trying to say is how are you working with industries for the benefit of other industries? Is there such a thing, and the same way as you are working with other countries?

Dr. MANNELLA. There are some examples. For example, the fuel cell program we talked about earlier, the original emphasis was for utilities but it is actually one of the candidates for Dr. Savitz in the total energy systems in the apartments and institutional buildings.

Batteries are another area, developed for electrical peaking applications in utilities, and now feed into electric vehicles.

PROJECT EVALUATION

Mr. YATES. If you don't have the ability to evaluate projects until 1978, how do you evaluate projects now?

Dr. SAVITZ. We evaluate projects now before we select them based on projected cost, projected penetration. That is part of the selection criteria that Dr. Mannella mentioned earlier in connection with the industry program.

We are now developing techniques and some of our projects are coming to completion, and we would evaluate what actually happens and how many savings will occur.

There are two sets of evaluations, one that we do while we are funding and before it, and then we want an evaluation of how good the effort has been.

CURRENT STATUS OF ELECTRIC VEHICLES

Mr. YATES. Let's turn to transportation energy.

You started to tell us about the current status of electric vehicles. I don't know whether you completed that answer. Will you check your answer in the record and see whether or not you want to amplify it?

Dr. MANNELLA. Be happy to.

Mr. YATES. Including the cost, the durability, safety, and efficiency.

[The information follows:]

ELECTRIC AND HYBRID VEHICLES

The present (April 1977) unit prices for electric and hybrid vehicles range from $3,000 to $28,000. These prices are heavily biased by the high labor content in each vehicle because most are built one at a time. Manufacturing tooling costs to reduce labor content are prohibitive in the present electric car market volume. The ERDA program to design and show proof of concept by 1979 with a 4-passenger commuter vehicle has targeted a $5,000 price for a volume production of 100,000 cars per year. The private sector has also targeted this price for the converted small van and other commercial vehicles in volume production.

The driving range for present day electric vehicles is 20 to 40 miles in urban driving where the vehicle must comingle with internal combustion engine traffic and accelerate to 30 mph in 18 seconds or less. The ERDA 4-passenger vehicle R. & D. program would produce a vehicle capable of 45 mph in 9 seconds with a range of 75 miles in urban driving.

Most present day electric and hybrid vehicles on the road have waivers for one or more Federal motor vehicle safety standards. The ERDA 2-year proof of concept program is carefully constructed to demonstrate a vehicle which does comply with the Federal motor vehicle safety standards. The Department of Transportation is now reviewing safety standards as they apply to electric vehicles, as required by Public Law 94–413.

The energy efficiency of the present day electric vehicle is approximately equal to the internal combustion engine compact car when measured from the basic energy source.

Mr. YATES. I didn't tell you about Yehudi Menuhin's $25,000 electric car.

Dr. MANNELLA. I don't think there are going to be too many of them.

ERDA'S POSITION ON ELECTRIC AND HYBRID VEHICLE ACT

Mr. YATES. Therefore we won't worry about it.

You have a document entitled "Introduction to the ERDA Electric and Hybrid Vehicle Demonstration Project" in which it is indicated that ERDA repeatedly testified against proposed legislation in this area on the basis that it is premature.

Dr. MANNELLA. That is really not completely accurate, Mr. Chairman.

Mr. YATES. In what ways is it not accurate?

Dr. MANNELLA. During the process of the development of the legislation when very large fleets were talked about, ERDA indicated its concern about the size and timing of the demonstration. In response to that the House Science and Technology Committee gave us some flexibility over the size of the fleets and considerable flexibility over the timing so that when the legislation was actually passed ERDA supported it.

TIMING OF ELECTRIC VEHICLE DEMONSTRATIONS

Mr. YATES. What are the benefits of demonstrating current vehicles over the advantages of waiting for significant improvements in technology?

Dr. MANNELLA. There are a lot of problems associated with a viable electrical system beyond the development of the vehicles per se. We have to get an understanding of all the institutional kinds of problems, the problems of licensing, repairability, et cetera.

We can do that with the present state of the art vehicles as well as any.

SIZE OF DEMONSTRATION PROGRAM

Mr. YATES. Could the data that you obtain on a smaller number of vehicles than 2,500 be valid? You pick a figure of 2,500 vehicles.

Dr. MANNELLA. That is rather carefully spelled out in the legislation.

Mr. YATES. What is your feeling about it? Even though it is spelled out in the legislation, 2,500 is a pretty big number.

Dr. MANNELLA. There is some provision for less than 2,500, but I think from a practical standpoint that we are actually going to demonstrate something rather close to 2,500.

Mr. YATES. How much will that cost? Do you have any idea?

Dr. MANNELLA. The vehicles and the associated costs of demonstration we are estimating will be $10,000 each. That is $25 million for the first demo and $50 million for the second demo.

Mr. YATES. Is it worth it?

Dr. MANNELLA. I think that when you look at some of the projections for the demand on liquid fuels through the year 1990, and the year 2000, then look at the contribution that electric vehicles could make in easing that demand that it is worth it.

Mr. YATES. I guess it depends on whether or not you think that we are going to lick the storage problem—right?

Dr. MANNELLA. I think even with the kinds of battery systems that we have now that there is a role for the electric vehicle in the relatively short duration trips—trips under 20 miles.

Mr. YATES. On pages 33 and 34, you list several options for financing demonstrations. Have you done any work toward deciding which options you would pursue?

Dr. MANNELLA. We have not actually developed the details of the demonstration very much at all because, really, until the advent of the Carter administration, we did not work on this program.

Mr. YATES. You still have an awful lot of R. & D. to do, haven't you?

Dr. MANNELLA. A substantial amount; that is correct.

EFFORTS IN BATTERY R. & D.

Mr. YATES. Would you put an explanation in the record of the status of the work and your intended expenditures in battery work for 1977 and 1978?

Dr. MANNELLA. We will be happy to.

[The information follows:]

STORAGE—EHV BATTERY STATUS AND FUNDING

For fiscal year 1977, internal reprograming of ERDA funds will provide about $9 million for support of storage R.D. & E., specifically for the EHV demonstration act. These funds are expected to be made available within the next 2 month—May and June 1977. Approximately the same amount—$9 million—is anticipated in fiscal year 1978 for EHV storage programs.

There are now 10 industrial contractors involved in phase I cost and design studies for three battery systems: Nickel/iron, nickel/zinc, and improved lead-acid. The latter have been selected because they can be made available in the necessary timeframe and in the required numbers. Most phase I studies have been completed and phase II efforts will begin when the reprogramed funds are received.

The National Battery Test Laboratory at Argonne National Laboratory will be equipped to test full vehicle-size batteries of 25–50 kWh and will perform qualification testing of EHV batteries. It will be partly operational by the end of 1977 and fully equipped at the close of 1978.

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RANGE AND DURABILITY OF BATTERIES

Mr. YATES. How long do you think it will be before we have a battery with an acceptable range and durability?

Dr. MANNELLA. We are hopeful that in the second demonstration—the demonstration of the advance vehicles, which is 6 years after the passage of the bill so that would be 1982—in the 5,000-vehicle fleet, we will have a small number of vehicles with advanced sodium sulfur batteries.

COST AND EFFICIENCY OF ELECTRIC VEHICLES

Mr. YATES. In your description of the work on the electric car, you are going to discuss the economics. Would you also discuss how they would compare with regular vehicles in cost and efficiency with projected increases in mileage?

Dr. MANNELLA. Be happy to.

Mr. YATES. And will electric vehicles be able to compete?

While you are talking about that, would you also tell us which is more efficient—to burn coal in an electric-generating facility to charge an electric car, or to convert coal to a synthetic fuel to burn in a regular car?

Dr. MANNELLA. We will take a look at that, also.

[The information follows:]

Comparison of Overall Efficiency of EHV & ICE Vehicles Utilizing Coal as the Energy Source

Coal can provide energy for electric cars through its use in generation of electricity, and for internal combustion engine vehicles through a synthetic fuel manufacturing process. The following chart, prepared by EXXON, shows representative lifetime energy consumption of future candidate vehicles, with various energy sources.

Lifetime Energy Consumption

	Gasoline Fueled Spark Ignition Engine Car		Hydrogen Fueled Spark Ignition Engine Car		Electric Car	Diesel Engine Car		Diesel/Electric Hybrid Car	
	Petroleum	Coal	Petroleum	Coal	Coal or Petroleum	Petroleum	Coal	Petroleum	Coal
	kWh								
Motive Energy	132,500	192,500	177,600	451,800	145,700	107,800	165,800	101,100	155,600
Production Energy:									
Car	15,200	15,200	16,200	16,200	13,300	15,600	15,600	14,200	14,200
Hydride or Batteries*	—	—	6,900	6,900	8,300	—	—	4,100	4,100
Total	147,700	207,700	200,700	474,900	167,300	123,400	181,400	119,400	173,900

* Battery production energy includes two sets of batteries — one set purchased with the car, and a replacement set required after 5 years. No energy credit was taken for the possibility of recycling battery materials.

It must be emphasized that any such analyses depends on many assumptions of process and conversion efficiencies, and on the type and mission of automobile. Therefore, a small change in the system or bias of the analysis could change the result, since there are not gross differences in the overall efficiencies of the systems shown.

APPLICATIONS OF ELECTRIC VEHICLES

Mr. YATES. Are you going to look at the possibility of the electric vehicle in cars other than in a passenger vehicle?

Dr. MANNELLA. Yes; working with the Post Office on the jeeps and whatnot, but we are going to primarily look at the passenger vehicle.

Mr. YATES. I saw a documentary on television which showed a German milk company delivering milk, and what happens is they have sets of big batteries and the truck drives up and they slide a set of the batteries out and they slide a new one in.

Dr. MANNELLA. We are in very close touch with particularly the British and Germans who have some advanced technology in this area, the British in the battery area and the Germans in the actual vehicle application. They have offered to concentrate on delivery vans. We will include delivery vans in our program, but the real benefits in the United States are going to stem from replacing some fraction of the passenger cars with electric vehicles.

In a delivery van you can control the route, and you can control the duty cycle, and you can invest in the battery exchange kind of equipment, and that is essentially what they are doing. They are having these trucks go around on these fixed routes, and when they need a new battery instead of recharging it overnight they just take a new battery pack and put it in.

This is not really a very attractive potential for passenger cars.

Mr. YATES. The thought suddenly occurred to me as to why you don't have a battery replacement exchange at a service station.

Dr. MANNELLA. It is technically feasible, but it is economically very unattractive.

COMPONENT DEVELOPMENT FOR ELECTRIC VEHICLES

Mr. YATES. Just think about it. In addition to the batteries, what other components need to be developed?

Dr. MANNELLA. The controllers and particularly the reliability of the entire system, reliability of the charging mechanism, the controllers.

We are baseline testing vehicles now, and the failures tend to be switches and things of that sort.

Mr. YATES. You also have to worry about the safety of the car.

Dr. MANNELLA. The act requires a special study of the safety implications to be done by the Department of Transportation, and they are working on that.

Mr. YATES. Can you get shocked by a battery? I guess you can.

Dr. MANNELLA. It is kind of difficult. It is very low voltage. If you reach across the whole battery pack you could conceivably get a substantial jolt.

Mr. YATES. When would you expect reasonable advances in all areas of R. & D. to coincide so that a vehicle with considerably improved characteristics could be demonstrated?

Dr. Seamans took me for a ride in an electric car last year. Whatever happened to that car?

Dr. MANNELLA. We probably still have it. We had them in the inaugural parade this year. We have two different kinds. I think a minimum of 6 years, 6 to 10 years.

INDUSTRY EFFORTS ON ELECTRIC VEHICLES

Mr. YATES. On page 10 of the document you indicate that the electric and hybrid vehicle industrial base does not exist. What is the current status of the industry?

Dr. MANNELLA. It is small, fragmentary, and barely in existence.

Mr. YATES. I don't know why either individual operators or the big companies who own automobile service stations couldn't sublease a portion of their area for battery replacement and battery chargers, just as they could with diesel or any other portion.

Dr. MANNELLA. You could.

Mr. YATES. Are they looking into that?

Dr. MANNELLA. Yes.

What we did was to this public meeting we invited a lot of people who don't normally respond to RFP's and announcement in the Commerce Business Daily, organizations that have facilities and contact with the consumers like Sears and Roebuck, Ryder, Avis, et cetera, and we hope some of them will get involved in this.

Mr. YATES. What additional infrastructure is needed to make an industry like that viable?

Dr. MANNELLA. These are some of the things we will find out.

Mr. YATES. What are the chances for a separate industry developing versus the current automotive industry eventually taking over production?

Dr. MANNELLA. Difficult to assess.

Mr. YATES. I agree with you.

How do you intend to meet the intent of the act with regard to small business participation?

Dr. MANNELLA. Special attention. We think that the electric vehicle industry as it exists today will respond very enthusiastically to our program and they all qualify as small businesses.

NEED FOR LOAN GUARANTEES FOR ELECTRIC AND HYBRID VEHICLE PROGRAM

Mr. YATES. Will you need loan guarantees?

Dr. MANNELLA. The industry certainly says so.

Mr. YATES. Automotive industry.

Dr. MANNELLA. The electric vehicle industry.

Mr. YATES. That isn't the automotive industry.

Dr. MANNELLA. No.

Mr. YATES. I don't know why they need them.

This is a long shot because I don't know that Congress is going to approve the loan guarantees.

Dr. MANNELLA. I am not sure that that is—hasn't that already been decided in the legislation?

Mr. GREER. The authorization is in the legislation authorizing the program.

Mr. YATES. In this legislation?

Mr. GREER. Yes.
Mr. YATES. Strike my question.

INDUSTRY EFFORTS ON ELECTRIC VEHICLES

Mr. YATES. Is there any part of the automotive industry that is engaged in the electric vehicle?
Dr. MANNELLA. Yes; several of them.
Mr. YATES. General Motors?
Dr. MANNELLA. General Motors has entirely within its own resources been developing an electrical vehicle.
Mr. YATES. Is it an electric diesel?
Dr. MANNELLA. No; it is an electric diesel, little 2-seater.
Mr. YATES. They have had buses.
Dr. MANNELLA. That I am not sure. The Ford Motor Co. has done extensive battery work and Chrysler is one of our subcontractors in electric vehicles.

URBAN DESIGN AND TRAFFIC MANAGEMENT R & D

Mr. YATES. Section 6 of the act refers to urban design and traffic management research and development.
Do you intend to do any such R. & D.?
Dr. MANNELLA. Not R. & D. We asked DOT to look into that.

FY 1977 AND 1978 BUDGET FOR ELECTRIC AND HYBRID VEHICLE PROGRAM

Mr. YATES. Your budget for 1978 for electric vehicles is $46,900,000.
Dr. MANNELLA. That is correct.
Mr. YATES. The act authorizes $40 million.
How are you going to get the extra $6.9 million?
Dr. MANNELLA. The $6.9 million is for our baseline program outside of the provisions of the act. It is for the total vehicle design and R. & D. In 1977 we had a baseline program with $5 million in it before the passage of the act.
Mr. YATES. Is there any reason for not asking for funding of the electric vehicle program under the 1977 supplemental? Did you ask for it?
Dr. MANNELLA. I will have to defer to the Controller.
Mr. GREER. OMB said since we had sufficient funds available within ERDA, they would approach it through a reprograming.
Mr. YATES. The first significant demonstration is fiscal year 1978. Does delay enter into it?
Mr. GREER. The reason for the reprograming in 1977 is to try and move it out. There are some companies that are kind of hanging on by a thread.

REDUCTION IN GASOLINE CONSUMPTION

Mr. YATES. Really? Would you explain how much and by which program you expect to achieve President Carter's goal of 10 percent reduction in gasoline consumption by 1985? Would you put that in the record?
Dr. MANNELLA. Yes, sir.

TEN PERCENT REDUCTION IN GASOLINE CONSUMPTION BY 1985

It is projected that the mandated automotive fuel economy will achieve well over 10 percent gasoline savings in that segment of use. However, only a small part of this goal will be achieved in regards to total gasoline consumption.

Use of alcohol/gasoline blends could contribute to the gasoline savings to the extent that alcohol could be produced or obtained. The present transportation energy conservation program on alternative fuels will provide the technical basis for use of alcohol. Domestic fuel alcohol production will require new plants to utilize nonpetroleum and nonnatural gas resources. (A 10 percent blend will require 10 times the present U.S. methanol production capacity.) Imported methanol could be made from foreign natural gas which is now being flared. Although this would not alleviate imports, it would stretch world energy resources.

In addition to the above, it is projected that a small additional percentage reduction in gasoline consumption (1–2 percent) may accrue as a result of retrofit devices and a program of driver training program on energy consumption awareness.

HEAT ENGINE SYSTEMS

Mr. YATES. We turn to the heat engine systems.

You talked about that earlier.

Mr. MANNELLA. The turbine and the Stirling engines.

Mr. YATES. What improvement in performance is needed before the gas turbine engine will be acceptable as against conventional engines?

Mr. MANNELLA. We think that a 30 percent improvement over 1976 would be suitable for industry to go into mass production, and that subsequent improvements up to about 50 or 60 percent would be possible.

Mr. YATES. When would it be able to be produced in any quantity?

Dr. MANNELLA. 1986–1987.

GAS TURBINES FOR VEHICLES

Mr. YATES. In light of increased requirements for fuel economy for conventional vehicles in future years, what is the competitive effect on the turbine car?

Dr. MANNELLA. It allows an efficient engine and a higher horsepower range, which will make it possible to have the kind of fleet mix that we need.

Mr. YATES. How does the development of a 50-mile-per-gallon-diesel engine, like Volkswagen's, for example, affect introduction of the turbine car?

Dr. MANNELLA. It is a 2,000-pound car, the Volkswagen Rabbit.

Mr. YATES. How much will this weigh?

Dr. MANNELLA. We are using as our base line 3,500 pounds. I am saying you cannot replicate the Volkswagen in a 3,500- or 4,000-pound car.

STIRLING ENGINE

Mr. YATES. You talked about the Stirling cycle engine.

Will you explain for the record what the Stirling engine is and what its advantages are, what its timing is of its potential development?

[The information follows:]

STIRLING ENGINE PROGRAM

The Stirling engine offers high potential for improving automobile fuel economy in the 1985–2000 time frame. The Stirling engine is a continuous combustion engine which is inherently suited to meet stringent exhaust emission standards. The combustion process can be well controlled; and peak combustion temperatures, which strongly influence NO_x formation can be limited to acceptable values with negligible impact on engine efficiency. The Stirling engine is also capable of utilizing broad-cut petroleum fuels or any synthetic transportation fuels that may be produced in the coming years, without concern for the octane or cetane limits required by conventional internal combustion engines, while meeting environmental standards for emissions of hydrocarbons, carbon monoxide, nitrogen oxides and noise.

Utilizing existing and near-term technology, mature version of Stirling engine could achieve initial production with 30 percent improvements in fuel economy in the 1986–87 time period, over the conventional piston engine powered vehicle.

Utilizing advanced high temperature materials technologies, an advanced version of this engine offers the potential for 50 percent improvements in fuel economy. Such an engine could achieve initial production in the 1991–92 time period.

Program cost through demonstration phase for a mature engine is approximately $150 million.

STIRLING ENGINE

Mr. YATES. It depends on what Ford does in releasing it, doesn't it?

Dr. MANNELLA. That is part of the situation.

Mr. YATES. How close are they to any agreement to release it for experiment?

Dr. MANNELLA. We are hopeful, although we have been hopeful for some time, that we can get that straightened out in the near future.

POTENTIAL ENERGY SAVINGS FROM VEHICULAR SYSTEMS R. & D.

Mr. YATES. Explain for the record the potential energy savings from your vehicular systems category?

Dr. MANNELLA. I will be happy to.

[The information follows:]

POSSIBLE ENERGY SAVINGS IN THE VEHICLE AND SYSTEMS CATEGORY

Potential energy savings for the present vehicular system programs is estimated to total approximately 2.2 million bbl/d based on anticipated total market penetration of all new cars manufactured by the year 1990.

VEHICULAR SYSTEMS

Mr. YATES. Are the types of systems likely to be installed by the automobile industry easily carried out, or will you have the same type of problems as with the turbines?

You can put that in the record.

[The information follows:]

VEHICULAR SYSTEMS—COMMERCIALIZATION BY INDUSTRY

The vehicular system hardware developments can easily be introduced into the automobile industry. In fact, commercialization plans are developed with each development to (1) seek active cooperative participation of the major vehicular manufacturers in the development programs, (2) test and demonstrate in fleet use the advanced vehicular system developed, and (3) to involve major vehicle manufacturer's in the commercialization process and decisionmaking.

We are convinced that by close liaison with the industry during the development of these systems that acceptance of the fruits of development by the industry will be a much easier task.

PROPOSAL FOR SPECIAL TYPE OF SPARK PLUG

Mr. YATES. We have received a copy of a proposal relating to a special type of spark plug.

Is that the double shot? They talked about that earlier. Will you evaluate that idea for the record?

Dr. MANNELLA. We will be happy to.

DOUBLE-SHOT SPARK PLUG CONCEPT

The Transportation Energy Conservation Division of the Energy Research and Development Administration has reviewed the statement entitled "New Energy Find" with great interest. In evaluating the theoretical rationale behind the claims of improved fuel economy, a number of questions have arisen which need to be resolved. These include the method of testing used by the inventor, the test conditions, and effects on exhaust emissions. Those were not addressed in the material provided.

Further investigation of the subject invention indicates that the same material is currently under evaluation by the National Bureau of Standards (NBS) Office of Energy Related Inventions. As a result, it is most appropriate to await the NBS evaluation before delving into their unanswered questions.

COMPARISON OF ELECTRIC, TURBINE AND STIRLING ENGINES

Mr. YATES. As well as telling us the three automotive systems described, electric, turbine, and Stirling, you are going to tell us which is the most likely to be adopted by the industry.

Dr. MANNELLA. Yes, sir.

Mr. YATES. That is kind of a guess, isn't it?

Dr. MANNELLA. Yes; it is. The answer will probably be not a single selection.

Mr. YATES. But all of them and probably a fourth.

Dr. MANNELLA. I don't know. It could include the diesel as a fourth perhaps.

Mr. YATES. How about the Mazda rotary?

Dr. MANNELLA. It doesn't look too efficient.

ALTERNATE PROPULSION SYSTEMS

The choice of future alternative propulsion systems by the automobile industry cannot now be confidently predicted. New propulsion systems such as the turbine, Stirling, and stratified charge are competing with improved versions of the conventional spark ignition and diesel engines. The industry prefers evolutionary changes which do not require totally new tooling in 1 year, yet it may be forced into major changes if the combined requirements of fuel economy and emissions cannot be met with the piston engine.

In general, it may be expected that the electric or hybrid vehicle could displace competitors for use in intercity and short-trip travel, missions normally accomplished by the second car in many households. Approximately 30 percent of the automobiles in the United States are in this category.

It is expected that larger trip lengths and larger size vehicles will continue to require some form of combustion heat engine. The requirements of economy and emissions will be quite difficult to achieve, and an alternative engine may be required. In the longer time period, this new engine may be operated on an atlternative fuel such as methanol or some form of synthetic gasoline. It is likely that different manufacturers would produce different types of engines or propulsion systems for different portions of the future market.

ALCOHOL AND ALCOHOL-GASOLINE R & D

Mr. YATES. What work are you doing on alcohol and alcohol-gasoline mixtures?

Dr. MANNELLA. Basically what we are trying to do is to understand what effect it would have on (A) a distribution system that we have, if we introduced it, and (B) whether or not there would be any long-term effects on the engine performance.

Mr. YATES. What is the projected cost?

Dr. MANNELLA. Of alcohol? It would be somewhat more expensive than gasoline.

Mr. YATES. Really?

Dr. MANNELLA. Yes, but don't forget a large part of the gasoline price is tax.

TESTING OF SYNTHETIC FUELS

Mr. YATES. Do you need a program to test synthetic fuels when industry is developing its own refining techniques, specifications or tests for fuels on their own?

Dr. MANNELLA. We want to test them for several reasons. We want to make sure the advanced heat engines we are working on, for example, the Stirling and the turbine, are optimized for these kinds of fuels.

Mr. YATES. How much money are you going to spend in this area?

Dr. MANNELLA. In testing of synthetic fuels?

Mr. YATES. Put it in the record if you can't find it.

Dr. MANNELLA. I will put that in the record, Mr. Chairman.

[The information follows:]

FISCAL YEAR 1977 AND FISCAL YEAR 1978 B/A FOR SYNTHETIC FUELS

The Division of Transportation Energy Conservation alternative fuels utilization program is based on feasibility studies that identify candidate alternatives for petroleum use in high vehicles as products from synthetic crudes, alcohol and, in the long term, hydrogen. In addition, activity is contemplated on improving fuel composition for greater energy efficiency.

The split in funds (in million dollars) among these fuels is:

	Petroleum	Alcohols	Synthetic fuels	Hydrogen	Total
Fiscal year 1977 budget authority	0.05	1.37	0.20	0.25	1.87
Fiscal year 1978 budget authority	.25	1.68	.20	.25	2.38

The emphasis is on alcohol fuels, straight and blended with gasoline, because technology to produce fuels is known and solutions to problems in using the fuels is of a straightforward engineering nature. Alcohol/gasoline blends have early potential as petroleum extenders. Token efforts in other fuels are aimed at the most significant need on a cost-effective basis.

HYDROGEN RESEARCH

Mr. YATES. And will you also put in the record what you are doing in the field of hydrogen research?

Dr. MANNELLA. Yes.

Mr. YATES. Also touching on the question which would be a problem if alcohol is a problem, the question of safety and the cost.

Dr. MANNELLA. I will be happy to.

Mr. YATES. And when the system, if it were adopted, would be likely to be adopted.

Dr. MANNELLA. Yes.
[The information follows:]

HYDROGEN AS A TRANSPORTATION FUEL

Hydrogen is an attractive fuel for vehicles because its combustion product is water vapor. Numerous automobiles have been modified to use hydrogen for fuel, but work is just starting to optimize an engine for hydrogen. A study is also underway as a basis for a decision on a demonstration of a hydrogen-fueled train. Hydrogen as a transportation fuel may be a viable option after 1990.

In order for hydrogen to be used as a transportation fuel, an inexpensive production method must be developed. Presently the Energy Research and Development Administration (ERDA) funds research on hydrogen production through the separation of hydrogen from oxygen in water by electrolysis. Two electrolysis systems are under development; present work is concentrated on improvement of electrolyzer efficiencies in an effort to substantially reduce the costs of this production method. The electrolysis method will require a non-depletable, economical source of electricity such as nuclear, solar, or geothermal power plants. A high-temperature, chemical separation process is also being investigated and shows promise for more advanced systems.

The development of a safe, lightweight storage system is also an important prerequisite to the use of hydrogen in transportation. Liquid storage would raise safety questions and gaseous storage would be impractical because of costs, weight and the inordinate sizes of the storage vessels needed for automobiles. Under the ERDA program, a relatively new method of storage has been proven technically feasible. Certain alloys can form hydrides by absorbing hydrogen which is later extracted by the application of heat. Important progress has been made in this solid storage approach. However, much more needs to be done to overcome the relatively high cost and significant weight penalties associated with the hydride developed to date. Such an effort is part of the current ERDA program. As progress is made, we hope to expand our hydrogen program.

Mr. YATES. Mr. McKay has submitted the following question for the record.
[The questions and answers follow:]

Question. Hydrogen appears to be emerging as a principle fuel of the future. Even today, hydrogen has been proven to be an economical, environmentally safe fuel for transportation. A transit bus in Provo, Utah and President Carter's 1977 Inaugural Cadillac Seville both run on hydrogen. Furthermore, with coal as our largest energy reserve, hydrogen can be produced in large enough quantities to help meet our energy needs. Over 90 percent of the large coal gasification plants in commercial operation are built to produce hydrogen at a cost of less than 5 cents per gallon of gasoline equivalent.

I would like to submit for the record a statement by Mr. Roger Billings on the future role that hydrogen must play to help America meet the challenge of energy sufficiency. Implicit in the statement by Mr. Billings is the question to ERDA: What is currently being done to encourage the research and development of hydrogen technology?

Answer. The significant potential of hydrogen as a fuel has long been recognized. ERDA has had a substantial research and development program underway for some time to determine whether that great potential can be brought to reality through the development of pratical systems.

That program is directed to various complex production, distribution, and storage issues that must be resolved before the widespread use of hydrogen can be realized.

The production issue is perhaps the most significant. Hydrogen can be produced from coal. However, the production of synthetic natural gas from coal would be much less costly and more energy efficient. Because of this and the distribution issue which I will describe in a moment, there is no present incentive for the commercial production of hydrogen from coal for use as a fuel. There is a need to produce hydrogen for use in coal liquefaction processes, and work has been started to fill this need.

For a substantial period, ERDA has had an effort underway to develop a hydrogen production process through the separation of the hydrogen from

the oxygen in water by electrolysis. Two electrolysis systems are under development and present work is concentrated on improvement of electrolyzer efficiencies in an effort to substantially reduce the costs of this production method. The electrolysis method will require a nondepletable economical source of electricity such as nuclear, solar, or geothermal powerplants. A high temperature chemical separation process is also being investigated and shows promise for more advanced systems.

The distribution problem exists because hydrogen in high concentration degrades materials used in present day pipelines. To address this problem, ERDA is conducting a search for cost effective materials through the operation of an experimental pipeline to test and evaluate materials, components, and welding methods to design pipeline systems which will withstand the effects of hydrogen.

The development of a safe, practical storage system is also an important prerequisite to the generalized use of hydrogen, particularly with regard to use in automobiles. Liquid storage would be unsafe and gaseous storage is impractical because of weight, expense, and the inordinate sizes of the storage vessels that would be needed for automobiles. Under the ERDA program, a relatively new method of storage has been proven technically feasible. This is the hydride method mentioned by Mr. Billings whereby certain alloys are impregnated with hydrogen which is later extracted by the application of heat. Important progress has been made in this solid storage approach but much more needs to be done to overcome the relatively high cost and significant weight penalties associated with the hydride developed to date. Such an effort is part of the current ERDA program.

As progress is made we hope to expand our hydrogen program. Our research to date leads us to believe that the widespread use of hydrogen as a fuel will require a rather long term development effort; however, hydrogen is widely used as a chemical commodity in the manufacture of ammonia, methanol, and a variety of other commodities. The present day processes for its production use natural gas and oil as raw materials. Also, high purity hydrogen for chemical uses commands a somewhat higher price. Therefore, the time required to achieve an economically competitive advanced hydrogen production process for chemical use, and thus conserve the fossil resources from which hydrogen is now derived, may be considerably shorter than is the case with its use as a fuel.

NON-HIGHWAY TRANSPORT SYSTEMS

Mr. YATES. You want a considerable increase for non-highway transport systems.

What are the potential savings in these areas?

Dr. MANNELLA. The rationale here is that non-highway transport systems, which account for about 25 percent of the energy now, by the year 2000 will account for 40 percent of the transportation energy. In other words, as we decrease the amount that is going to be used by the highway vehicles, the non-highway sector is going to grow. We are asking for enough money to get some studies underway to look at, mostly in conjunction with DOT, energy saving opportunities in airlines, railroads, and——

Mr. YATES. Do they contribute as much money to this as you do?

Dr. MANNELLA. Not usually. In the case of the Maritime Administration, no.

Mr. YATES. How much of the work will be transferred from other agencies to the proposed Department of Energy; have you any idea?

Dr. MANNELLA. How much of the work that is included here?

Mr. YATES. Yes.

Dr. MANNELLA. All of it.

Mr. YATES. From the other agencies.

Dr. MANNELLA. From the other agencies? I will submit that for the record.

[The information follows:]

NON-HIGHWAY TRANSPORTATION ENERGY CONSERVATION TRANSFERS

We do not anticipate any major transfer of authority or program responsibility from other agences to DOE for the nonhighway transportation area. DOE's nonhighway transportation energy conservation R. & D. program would continue to cooperate with other agencies who support work in this area (FRA, FHWA, etc.).

Mr. YATES. We will meet tomorrow at 10 o'clock.

[Whereupon, at 5:40 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Wednesday, April 27, 1977.]

WEDNESDAY, APRIL 27, 1977.

ELECTRIC VEHICLE DEMONSTRATIONS

Mr. YATES. The hearing will come to order.

Let's talk about the electric car for a minute. I listened to the testimoney yesterday and I was a little concerned about some aspects of it. ERDA says advanced concepts won't be developed until 1982, particularly the batteries, therefore it is too early to demonstrate and that reasonable data can't be gotten in less than 7,500 cars.

That is an enormous amount of demonstration before we know where we are going, isn't it?

Mr. FRI. Demonstrating a car requires verifying reliability in use over a period of time and a number of applications. Whether 7,500 or 10,000 or 5,000 is the exact figure is hard to say. But reliability, serviceability and, operability in service is really what you have to demonstrate.

Mr. YATES. That is what your document says.

I suppose you have to take what you have, then, and that is all you can do about it. That doesn't really leave any room for imagination or initiative.

Mr. FRI. In the first round of demonstration, the first 2,500 cars under the Electric and Hybrid Vehicle Act, we will have an advanced lead acid battery, and better engineering of the vehicle itself, but it still won't be a long-range highly efficient mode of operation.

We are figuring out what applications to pick for demonstration that represent nitches in the market where electric vehicle might turn out to be attractive—postal vehicles, delivery vehicles, and other applications for groups of people who have very minimal transportation needs for which an electric car would be adequate.

If you demonstrate successes in those nitches, when the additional 5,000 come along you could broaden the demonstration to other applications. The thing you don't want to do with the first 2,500 is to try to demonstrate that you have a car that is useful for commuting

from Gaithersburg or Rockville to Capitol Hill each and every day because you just may not——

Mr. YATES. The cost concerns me. I am troubled and cannot understand really why you need 2,500 vehicles rather than, say, 200, especially when you don't know whether you have a good battery. Why do you have to build all these vehicles? I know what the act provides but sometimes we take a second look at acts.

Mr. FRI. We are conducting a risk assessment study that is supposed to be done in August. What we would propose to do is come back to Congress and say: We have gone through a detailed analysis of what we believe are the right kind of demonstrations. It may not add up to 2,500 vehicles in the first group or 5,000 vehicles in the second.

BATTERY SYSTEMS FOR ELECTRIC VEHICLES

Mr. YATES. Are you going to build your vehicles until you have a good battery?

Mr. FRI. I think under the provisions of the act we have to build some number of vehicles in the first group.

Mr. YATES. You know what the car with that battery will do now, don't you? Why do you have to build any cars until you have an improved battery?

Mr. FRI. An improved battery is the key to range and hours of operation between recharge, but the electric car people, with all due respect to them, are not necessarily the world's greatest automotive engineers. They come more from the electric battery business than vehicle engineering. I think there are a lot of things that can be done to engineer the automobile itself for better performance.

We have two or three of these vehicles in ERDA and I ride around in them a fair amount because they are pretty well suited for short commutes. They are noisy as the devil inside. It has nothing to do with the battery; it has to do with the propulsion system. Those are the kinds of things that can be resolved to make the car more attractive without improving the battery.

SIZE OF ELECTRIC VEHICLE DEMONSTRATION PROGRAM

Mr. YATES. So your research will be done with the battery and in curbing the noise on the relays and propulsion units and so forth, but why do you need 2,500 cars?

Mr. FRI. We don't know it will take 2,500 cars. That is why we are taking a hard look via the risk study.

Our evaluation will be completed in August, so it is a matter of budgetary timing as much as anything else. We felt the only thing we could do in the absence of that analysis was to block out funding sufficient for something like a 2,500-car buy, which is the requirement of the act, and then come back and tell you we need it all or we don't need it all.

Mr. YATES. How much of your appropriation request is to keep the electric car manufacturers alive?

Mr. FRI. Very little of the demonstration funding actually falls into that category. There are a series of research contracts that will put out planning grants and a loan guarantee program, some of which we propose for initial funding in 1977 and more of which is in the 1978

budget. To the extent the electric vehicle manufacturers need to be kept alive by Government funding, it will be the flow of funds from those kinds of activities in the demonstration program that will do it.

Dr. MANNELLA. I wonder if I might add a few words. I think the 1982 date you referenced was an answer that I gave you yesterday when you asked when we might see these various advanced batteries in production.

The type I was referring to was the sulfur batteries that would have greater power density and energy density. The intent of the Congress in passing the act I think was prior to the introduction of these advanced batteries to determine from a demonstration of some reasonable size what all of the institutional problems and requirements might be to make it possible for a substantial proportion of our fleet to be electric vehicles, say in the year 1990 or something of that sort.

We have a very extensive highway system now geared to the internal combustion engine, its maintenance, repair, and operation. It would, I think, go without saying today's electric vehicles and quite possibly several future generations could not be inserted in that system by themselves and compete very effectively, that they are going to have some different kinds of problems with regard to licensing, safety, insurance, reliability, and repairs, as well as the consumer reaction to these types of vehicles.

Those are the types of things we hope to pin down in these demonstrations.

Mr. YATES. How can you pin them down when your electric vehicle is obviously inadequate and not attractive to the buying public not only because of the vehicle itself but because of the cost.

Dr. MANNELLA. I think there is a body of opinion that says that the electric vehicle is not necessarily unattractive to some reasonable segment of the driving public and is suitable for certain types of surface transportation.

COST OF ELECTRIC VEHICLES

Mr. YATES. How much does an electric vehicle cost now?

Dr. MANNELLA. It is difficult to tell because the market today is essentially composed of custom-type vehicles. I might point out in 1974, in the wake of the oil embargo, Sebring Vanguard Corp. manufactured about 2,000 city cars which sold for $3,000.

Mr. YATES. What do you mean by a city car?

Dr. MANNELLA. That is the name of their little two-seater vehicle.

UTILIZATION OF ELECTRIC VEHICLES

Mr. MCDADE. A friend of mine owns one and drives to and from his office and to the golf course. For what it is worth, at least 4 years ago we had Westinghouse from our State come to Washington and they said they had an electric car that was ready to go and the only problem that prevented it was the lack of infrastructure you described yesterday for servicing.

Dr. MANNELLA. I believe Congressman Rhodes drives a city car.

Dr. MANNELLA. Secretary Adams of DOT drives an electric car.

Mr. YATES. The Administrator says he drives it too but he knows he is only going to drive six blocks.

SIZE OF ELECTRIC VEHICLE DEMONSTRATION PROGRAM

Mr. MURTHA. I have to agree with the chairman. I am concerned that ERDA is getting out of their field by producing 2,500. It would seem to me you would be better off concentrating on a few cars and trying to make those attractive to the public.

Mr. FRI. As I say, we are not committed to the idea of building 2,500 automobiles. We are trying to figure out what the right answer really is, given what seems to be the congressional intent we buy some number for demonstration purposes.

Mr. YATES. Let's do this. Why don't you tell us how much money you need until you make your survey, the review that you are going to make in August, and then look at the possibility of a supplemental. You won't need very much money until August for this project, will you?

Mr. FRI. Until we have decided on the design and size of the demonstration, obviously we will not be obligating funds for demonstration purposes.

Mr. YATES How can we give you any money until you tell us that you have decided on that?

Mr. FRI. That is a reasonable question. However as an agency we find the statute says it really ought to be 2,500 vehicles and we said maybe it is or isn't.

Mr. YATES. Quite frankly, the 2,500 you find in the act is an authorizing amount.

Mr. FRI. In this case the Congress went to the trouble of putting in some criteria that would have to be met to make it less than 2,500.

Mr. YATES. Such as what?

Dr. MANNELLA. As I recall, the intent was not for the Government to purchase any vehicles that might otherwise be purchased by private citizens, and if we can determine that such is the case, the administrator of ERDA can come back to the Congress and give his reasons and I guess prove a number of less than 2,500 is appropriate.

Mr. FRI. If the electric car is a success without us, we don't have to buy 2,500.

FISCAL YEAR 1977 AND 1978 FOR ELECTRIC AND HYBRID VEHICLES

Dr. MANNELLA. If we are talking about the fiscal year 1977 funding—

Mr. YATES. Let's talk about fiscal year 1977. You are also talking about 1978 too.

Dr. MANNELLA. The fiscal year 1978 request does contain a substantial amount of funds in anticipation of the demonstration. The fiscal year 1977 funding does not. The fiscal year 1977 funding is essentially for batteries, for component R. & D. and for some support activities to plan the demonstrations in some detail.

Mr. YATES. How much is that?

Dr. MANNELLA. Mr. Esposito was not here yesterday. He is the Director of Transportation.

Can you give us those numbers?

Mr. ESPOSITO. In 1977 the total electric vehicle budget will be $25 million if the $20 million reprograming were added to the five that

we already have. Of that, $9 million goes to battery research, which is clearly the thing we have to get working on. The other goes into vehicle systems research, the components, many of the studies that we are doing in order to see if the bill is viable. We are assessing state of art to see how far we have to go.

The component research may come down.

Dr. MANNELLA. But there is little or no funding in the 1977 request for the demonstration per se.

Mr. ESPOSITO. The only funding that you would label demonstration in 1977 is some for demonstration planning. If we begin the demonstration in 1978, we must have a reliable plan made and sites picked. The 1977 funding also provides for the risk assessments.

Mr. FRI. That is largely for the risk assessment, is it not?

Mr. ESPOSITO. The risk assessment is in there also.

Mr. YATES. Three months from now you will be making a risk assessment.

Dr. MANNELLA. We will have that study completed.

Mr. YATES. Mr. Murtha?

Mr. MURTHA. Would you repeat those figures.

Mr. YATES. In 1977 this is the reprograming.

Dr. MANNELLA. Five of which has been appropriated.

Mr. ESPOSITO. There is a $5 million appropriation that was already there. Adding the $20 million reprograming gives a total of $25 million of which $9 million will be energy storage, another $8 million goes into vehicle systems development work and component research and development, and a comprehensive state of the art study; another $6.5 million goes into developing vehicle specifications, advanced technology development and special studies. Some near-term studies required under the act are due this September.

Mr. MURTHA. That adds up to more than $20 million.

Dr. MANNELLA. In fiscal year 1977 $5 million is included in the base program and $20 million is being requested in the reprograming. The total is $25 million.

Mr. YATES. What has the $5 million gone for so far?

Dr. MANNELLA. As I mentioned yesterday, we had a baseline program ongoing before the passage of the act which consisted of three preliminary studies of a total electric design. Some of the $5 million is being used to continue those studies. Some of it is being used to meet some of the near-term requirements of the act such as the base-line vehicle testing and the risk assessment that we referred to earlier, which will be finished in August.

Mr. MURTHA. We are not concerned about what you are doing because you are not moving into the manufacture of cars.

Mr. YATES. You are not going into mass production.

Dr. MANNELLA. We would never manufacture the cars; we will purchase them.

Mr. FRI. $13 million in fiscal year 1978 is for the demonstration. We will submit further information for the record.

[The information follows:]

ELECTRIC AND HYBRID VEHICLE FUNDING REQUIREMENTS

In fiscal year 1978 only $27 million would be required instead of $40 million if there were no activities related to the demonstration required by Public Law 94-413. If the demonstration were funded via a fiscal year 1978 supplemental budget, there is every probability that a 1 year slip of the demonstration would result, due to the lead time required to obtain funds, and inability to implement advanced procurement activities to affect long procurement lead times.

Mr. MURTHA. Under the procedure, you contemplate to order a certain number of cars from an electric vehicle manufacturer, don't you?

Dr. MANNELLA. The act tells us when to begin the ordering and when to complete the ordering and receive all the vehicles and go into the demonstration. Those time frames are spelled out.

Mr. MURTHA. Whether the car works or not?

Dr. MANNELLA. I am sure if we could show the car wouldn't work we would be back to Congress and talk about it. But we are testing base-line vehicles now and of the 14 or so we are testing, a number of them certainly look like they could be viable vehicles. We are testing foreign vehicles as well.

Mr. YATES. Some look like viable vehicles? Which ones? What is a viable vehicle?

Dr. MANNELLA. One that looks like it might be competitive.

Mr. YATES. That could run more than six blocks.

Dr. MANNELLA. Most of them will run a good deal more than six blocks.

Mr. YATES. What is the maximum range you have now?

Dr. MANNELLA. You trade it off with speed. There is only so much energy. You build a vehicle that won't accelerate very fast or go very far.

Mr. YATES. How far is very far?

Dr. MANNELLA. Seventy-five miles is a high range for an electric vehicle today. Seventy-five round trip.

Mr. YATES. Is that considered to be a viable vehicle?

Dr. MANNELLA. I think so.

Mr. FRI. For some applications.

Dr. MANNELLA. As I mentioned yesterday, up to perhaps 40 percent of the daily trips that are made are less than 20 miles. It would fall into that kind of category.

Mr. YATES. You can almost do that with a golf cart.

Dr. MANNELLA. You couldn't license it to run on the street, though.

Mr. EVANS. You are asking about the test reliability. Under the act, as I understand its concept, if it cannot be sold privately the theory is the Government would buy up to a certain specific number of these things to guarantee whoever developed them wouldn't be left with a lot of lemons. Isn't that the test in the act? Is there a period of time during which these are offered to the public and if the public doesn't buy them we do?

Dr. MANNELLA. The act says we will buy up to 2,500 unless it is clear that we would be buying cars that private citizens would otherwise be buying.

Mr. EVANS. How long does it take to find that out?

Dr. MANNELLA. I am not sure whether we could ever really find it out.

Mr. FRI. It is a very difficult question for us to address.

Mr. MURTHA. I don't think you ought to appropriate money to buy a number of cars that the public won't buy.

Mr. YATES. I am sure ERDA doesn't want you to.

Dr. MANNELLA. We have a car in the front of the building today which is the first generation of electric vehicles. This car is not as good

as you would see in the first demonstration. If any of you have not had the opportunity to ride an electric vehicle, I extend an invitation to you today.

Mr. MURTHA. If there is someone out there, I will try it out while you continue.

Mr. YATES. You see how we are troubled. It is a very difficult concept.

Mr. FRI. Let me make a statement on viability. It really comes in two parts. Technical viability means you have a car that has a 50- or 75-mile range day after day.

Commercial viability means that you have an application for a 50-mile range vehicle. You have to find somebody who, day in and day out, can use a car that only goes 50 miles and never wants to take it to Frederick, Md. or over the road because he has another car for that purpose or something.

The real thrust of the risk assessment is to look at the viable applications of these kinds of workable electric vehicles.

Mr. EVANS. How do you do that?

Mr. FRI. You have to analyze the way people drive and the various market segments that are inside the automotive market.

Mr. EVANS. Is saleability a test of that?

Mr. FRI. It is the ultimate test.

Mr. EVANS. Does that have to be proved before you make a decision on recommending? It is sort of a catch 22?

Mr. FRI. As I say, the burden of proof we assume under the act is a nearly impossible one to execute. However, we think there are valid applications, but maybe not for 2,500 cars.

Mr. YATES. Do you have to order 2,500 cars from a manufacturer before he would undertake a contract?

Mr. FRI. These cars may be split among several manufacturers.

Mr. YATES. What is the minimum?

Dr. MANNELLA. It is very difficult to determine a minimum number for a manufacturer.

ALTERNATIVE FUELS FOR VEHICLES

Mr. YATES. What other propulsion experiments are you using? Are you using wood alcohol?

Dr. MANNELLA. Yes. Alcohol blended with gasoline.

Mr. YATES. What do those studies show?

Dr. MANNELLA. It is too early to draw conclusions. We are looking at the impact on the existing distribution system, and the impact on the vehicle. Whether there is any long-term change in the energy that would have to be made, such as distribution system, is something that deserves careful analysis because alcohol mixes with water but gasoline does not. If you start putting amounts of alcohol in water in the storage tanks of filling stations, there is residual water in those tanks which never gets pumped up. That could be picked up by the alcohol and then in operation of the vehicle could cause quite a few problems.

Mr. YATES. What about steam?

Dr. MANNELLA. We have nothing going on in the steam engine for automotive propulsion.

Mr. YATES. Why is that?

Dr. MANNELLA. We had some studies and our conclusion was it was just not attractive. These units tend to be extremely heavy. The boiler

is very heavy, and perhaps for certain special-duty vehicles like buses they might be attractive but not for passenger cars.

Mr. YATES. What about other propulsion or fuels?

Dr. MANNELLA. In other fuels, we are doing testing of synthetic fuels we think will be coming along. The position we finally came out on is that we are not doing anything on diesel. We did have some work going last year to see what it would work to get the diesel engine down to a point for Knox emission, but we are very impressed with the work Volkswagen has done on the Rabbit and with the work General Motors has been doing; and we understand other manufacturers are working on diesels. It just seems to be an area the Federal Government doesn't have to be involved in at this time; that the industries are pursuing these adequately. The same is true in stratified charge and other types of engine concepts.

INDUSTRY INVOLVEMENT IN ELECTRIC VEHICLES

Mr. YATES. Why aren't the automobile manufacturers working on an electric car?

Dr. MANNELLA. They are, but the extent of their commitment is difficult to tell. General Motors has developed a 2-seater electric vehicle. They have not approached us and are not showing any sign of interest in our demonstration program. Ford Motor Co. has done a lot of work and is working with ERDA on battery development, and Chrysler Corp. is actively involved in base-line electric vehicle programs in a consortium with General Electric and ESB, a battery company, each having skills and talents they bring to this problem. They are working on it.

Mr. YATES. But they would rather not invest their money; they would rather have the Government do it?

Dr. MANNELLA. I think part of the problem with the industry is they are by tradition in investment very much wedded to the internal combustion engine.

EFFORTS ON FIBERGLASS AUTOMOBILE BODIES

Mr. YATES. What about other aspects of the automobile problem? Are you working on lighter materials or are the manufacturers working? For example, I read somewhere that there is a possibility of moving from steel to fiberglass for the body.

Dr. MANNELLA. The Department of Transportation is doing some extremely innovative work in materials. Their primary interest is in lightening the vehicle without sacrificing any strength. We are very closely connected with the RSV program at DOT where they are working on the vehicle structure but not the engine. The two programs complement each other very well. Manufacturers are also doing work on materials, and we do see increasing amounts of nonmetallic material appearing each year on vehicles.

For example, the so-called sight shields that cover the new no-damage bumpers are made of plastic, and other manufacturers I think are about to go into production with whole body sections like trunk lids that are made of fiberglass.

Mr. YATES. Not fenders?

Dr. MANNELLA. Fenders possibly also. I am really not current on that.

Mr. YATES. Isn't there a car that has a fiberglass body?

Dr. MANNELLA. Yes. Corvette is all fiberglass; has been from the very inception.

Mr. YATES. Is this more expensive?

Dr. MANNELLA. Again, now, yes. If there was extensive use of it, the answer would probably be no. Repairing those bodies is rather expensive because there is little demand for that kind of skill, but if the industry were to commit itself in a significant way to the use of these kinds of materials, I don't see why it should be any more expensive.

Mr. YATES. Fiberglass doesn't bend?

Dr. MANNELLA. It shatters.

Mr. EVANS. Which is least energy intensive?

Dr. MANNELLA. I am not sure I have a ready answer.

Mr. FRI. Both glass and steel require an awful lot of energy to make.

Dr. MANNELLA. The steel body requires heated forming steps. Fiberglass can generally be formed in one single piece, but the net energy balance I don't have the information on.

Mr. YATES. Could that be supplied for the record?

Dr. MANNELLA. We will try to get it. I think DOT probably has it.

[The information follows:]

ENERGY REQUIREMENTS FOR A STEEL VS. FIBERGLASS AUTO BODY

A typical 3,000 lb. automobile today has the following body shell weights:

	Funde [1]
If plain carbon steel	1,100
If plastic (fiberglass)	460

[1] Provided by Andrea Watson of IRT Corp. May 6, 1977.

To produce this amount of body covering takes:

	Btu/lb [1]	Btu's (10^9)
Plain carbon steel	21,000	23.1
Plastic	25,000	11.5

[1] p.G 34, Impacts of Material Substitution in Automobile Manufacture on Resource Recovery, IRT Corp. for EPA, October 1975.

ENVIRONMENTAL IMPACTS OF ELECTRIC VEHICLES

Mr. YATES. Incidentally, I don't think we asked you last night as to how much money you have set aside for environmental impact statements for your demonstration of electric vehicles.

Mr. ESPOSITO. I believe it is about $300,000.

Mr. YATES. Is that enough?

Mr. ESPOSITO. That amount in 1978.

Mr. YATES. Nothing for 1977?

Mr. ESPOSITO. We are spending money now.

Dr. MANNELLA. Yes.

Mr. ESPOSITO. I don't have the 1977 number in front of me.

Dr. MANNELLA. We can provide that figure.

ELECTRIC AND HYBRID VEHICLE ENVIRONMENTAL STUDIES

An Environmental Development Plan for Electric and Hybrid Vehicles is currently being established within ERDA. Work is being initiated on an Environ-

mental Impact Assesment this fiscal year for the first demonstration under Public Law 94–413. If it is so indicated by the assessment, an Environmental Impact Statement will be conducted early in fiscal year 1978. A related study called for by Public Law 94–413, section 13b, is being conducted to determine the materials and pollution effects resulting from the use of electric vehicles.

Activity	Fiscal year budget authority (thousands)	
	1977	1978
Environmental development plan	$300	$300
Environmental impact assessment	300	300
Materials and pollution study (Public Law 94–413, sec. 13b)	180	
Total	780	600

DATA ANALYSIS IN TRANSPORTATION PROGRAM

Mr. YATES. What is the overall use you intend to make for all the data you want funded?

Dr. MANNELLA. The primary outlook for this is a publication that we put out periodically called The Transportation Energy Conservation Data Book. It is used rather extensively by us and the Executive Branch for data relating to various initiatives in this field. I think it is being used increasingly by people outside the Federal Government in universities and industry, for example.

FUEL CELLS

Mr. YATES. Now let's talk about Improved Conversion Efficiency. You want $55,200,000 for that. My impression is when last we met last year there wasn't a great deal of enthusiasm for fuel cells. Apparently there is now. Have there been developments in the field since that time or are you more ready for funding now?

Dr. MANNELLA. I think there has been some development plus a greater awareness and appreciation of potential for fuel cells.

In terms of the use of this so-called first generation type of machine for utility peaking, there really always has been a substantial amount of interest in the utilities. They have, as I mentioned yesterday, placed tentative orders for 50 or more of these units, providing that we can meet our goals.

Beyond that, several other things have occurred. In a different size range, about 40 kw, the fuel cell looks like a very, very effective way of providing total energy requirements for the schools and apartment complexes, condominiums, and various types of institutional buildings.

We have studied the ECAS study which says in the second generation the molten carbonate has some of the most attractive potential for both efficiency and implementation.

Mr. YATES. On page 73 of the justifications you refer to fuel cells replacing existing 22-percent efficient hardware with 38-percent efficient hardware. Is that the peak you contemplate?

Dr. MANNELLA. No; that is the first generation machines. We think we can get first generation machines probably up to 40 and the second generation, the molten carbonate, in the 50's in the time frame of 1987. The gas turbines mentioned are presently used for peaking.

Mr. YATES. You state that fuel cost pass through by utilities discourages conversion efficiency improvements. Would removal of such pass throughs accelerate efficiency changes or just reduce profits, thus making it harder to raise capital for improvements of any sort?

Dr. MANNELLA. It would. I think there are other institutional forces at work. Certainly the shortage of natural gas and the possible shortage or higher price of light distillates would, we think, have beneficial effects here also.

Mr. YATES. Would you place in the record an explanation of how a fuel cell works?

Dr. MANNELLA. I would be happy to, Mr. Chairman.

Mr. YATES. Also would you include the cost comparisons for fuel cells against the type of capacity that they would replace as to whether they are more or less capital intensive.

Also would you explain how the second generation molten carbonate fuel cell is better, or different, than first-generation phosphoric acid cells.

FUEL CELL OPERATING PRINCIPLES

In the combustion process used in conventional power plants, power generation requires three steps. Fuel and air combine releasing their stored chemical energy as heat energy which is used to make steam. The mechanical energy of steam turning a turbine is converted to electric energy.

In the electrochemical process which takes place in a fuel cell, the chemical energy that bonds atoms of hydrogen (from a hydrocarbon fuel such as coal, oil, or gas) and oxygen (from air) is converted directly to electrical energy.

A fuel cell is a sandwich consisting of an anode, electrolyte, and cathode, much like a battery. Hydrogen-rich fuel is fed down the anode side of the cell, where the hydrogen loses its electrons, leaving the anode with a negative charge. Air is fed down the cathode side, where its oxygen picks up electrons, leaving the cathode with a positive charge. The excess electrons at the anode flow towards the cathode, creating electric power. Meanwhile, hydrogen ions produced at the anode (when electrons are lost) and oxygen ions from the cathode migrate together in the electrolyte. When these ions combine, they form water, which leaves the cell as steam because of the heat of the cell processes.

The fuel cell generator system has three parts: a fuel processor, a fuel cell stack, and a power inverter. Hydrocarbon fuel and steam (recycled from the fuel cell operation) are first fed into the fuel processor and converted to hydrogen and carbon dioxide. This hydrogen-rich mixture is then fed into the fuel cell stack, where the fuel cells are piled one on top of another. As electricity is produced, exhaust from the stack includes carbon dioxide, nitrogen, and water, condensed from steam.

DC power electricity from fuel cell electrochemistry must be converted to AC power for utility applications. This conversion takes place in the third part of the system, the power inverter, which can convert large amounts of DC power to AC at nearly 96% efficiency.

The three segment fuel cell system can already produce electricity, from fuel to utility grid, at an efficiency of 38-40%, over 75% of the power plant's load capacity. This ability to retain high efficiency at part power is a very important fuel cell characteristic.

Within 10 years, this efficiency is expected to be 50-55%. In addition, emmissions from the generating process are well within present environmental limits, 10 times cleaner than the EPA requires.

FUEL CELL COST COMPARISONS

Fuel cell cost comparisons, against the type of equipment they would replace or displace, vary with the environmental constraints of the site. In areas of high environmental impact, the fuel cell is projected to provide considerably lower cost service than its potential competitors due to the lack of need for "scrubbers" and complex cooling towers. It is also virtually noiseless.

Specifically, first generation fuel cells will be used in electric utilities in the cycling duties of intermediate and peaking generation. This is presently the most costly type of generation, and is accomplished almost exclusively with oil and natural gas at an average efficiency in the range of 25%. An average comparison of fuel cells to cycling steam and combined cycle plants, including credits for associated savings in transmission and reserve requirements, and assuming $250 - $300/kW capital cost for fuel cells, shows a fuel cell associated capital savings of $130/kW to $220/kW.

In small size fuel cell applications for natural gas-fueled total energy systems, an average of 30% of the natural gas usage in a commercial building can be saved. This savings, in cost, is greater than the associated cost of leasing and operating the fuel cell in the total energy system. Therefore, significant natural gas will be saved, and the building operator will potentially pay less of an energy bill. This assumes a fuel cell cost of $300 per kW and a useful operating lifetime (with maintenance) of 20,000 to 40,000 hours at present natural gas prices.

SECOND GENERATION (MOLTEN CARBONATE) FUEL CELLS

Second generation "molten carbonate" fuel cells differ from first generation in fuel, temperature of operation, general application, and cost. First generation "phosphoric acid" fuel cells operate below 400°F, and use a wide range of liquid and gaseous fuels. They will cost $250 to $350 per kW in full production, after some identified technology improvements. They will be used largely to supply electricity to "cycling" loads; i.e., utility peaking and intermediate generation, total energy systems for buildings, industrial cogeneration, community integrated systems, waste gas utilization, and others. They have a major advantage in addition to their high efficiency, being environmentally benign. This allows them to be sited close to people, making utilization of waste heat more readily accomplished.

By comparison, second generation "molten carbonate" fuel cells are more suited to "base load" types of applications. They will operate from a wide range of fuels, including coal. Their temperature of operation will be about 1000°F, and their waste heat will be in the form of steam in a cooling system. They will not be as readily cycled as first generation equipment, but their cost is projected to be $200 - $250/kW for oil and gas using systems, and $450 - 600/kW for coal using systems. They appear very attractive for electric utility base load applications and industrial cogeneration.

COAL USAGE IN SECOND GENERATION FUEL CELLS

In a second-generation, molten carbonate fuel cell, the fuel processor consists of a rudimentary coal gasifier which supplies a low-Btu gas to the fuel cell stack. This gasifier is projected to be considerably less expensive than gasifiers for pipeline gas because: a. it will be low pressure; b. it supplies low-Btu gas and will not need methanation; c. its gas cleanup will be a simpler process; and, d. due to the high system efficiency, the gasifier will be smaller because less coal is needed per unit of electricity. At present, the leading gasifier for this application appears to be an Institute of Gas Technology U-Gas gasifier.

4.8 mW, 40 kW, and 120 kW FUEL CELLS

The 4.8 mW fuel cell module is the basic module of what will be electric utility fuel cell generators. Six of these modules together will provide up to 27 mW of AC power.

Fuel cell modules in the range of 40 - 120 kW are being developed by three corporations as candidates for on-site, cogeneration power plants in buildings and industry. These will provide on-site power as opposed to the 4.8 mW which will be a substation module.

A 4.8 MEGAWATT FUEL CELL DEMONSTRATION

Mr. YATES. Have you a host utility for this project yet? If not, do you have likely volunteers?

Dr. MANNELLA. We haven't selected one yet. The RFP went out about a month ago.

Dr. BELDING. Bids haven't come in yet. They should come in shortly. We think we are going to get about 50. We don't have any problem with that.

Mr. YATES. Are you going to cost share with 50?

Dr. BELDING. Yes.

Dr. MANNELLA. We will cost share with the one we will select.

Dr. BELDING. Actually we are already cost sharing with the utilities and with EPRI.

Mr. YATES. What is the next step beyond this demonstration? What will be the Government involvement?

Dr. MANNELLA. The next step would be to demonstrate on line a unit that I think would be more representative of what the utilities will actually be putting in place. It is a 26-megawatt fuel cell unit. This 4.8 unit is one big enough to put on line for awhile and to see how it interacts with the rest of the generating system and to determine over a period of say a year how the machine holds up and behaves when it is on line.

But the type that we think will actually be commercialized is the 26-megawatt unit, and we would hope to be involved in the commercialization of that unit in 1979.

Mr. YATES. Would you in your explanation also include how coal would be used in conjunction with second-generation molten carbonate fuel cells.

Also explain the difference between the 4.8-megawatt facility and the 40-and the 120-kilowatt.

FUEL CELL APPLICATIONS

You are talking about fuel cell powerplants in the transportation sector. How would you use them? Would you use them in a car?

Dr. BELDING. The Electric and Hybrid Act allows for fuel cells.

Mr. YATES. How big is the fuel cell?

Dr. BELDING. As big as you want it to be. We have made fuel cells about this size [indicating] which put out 11 kilowatts—excuse me, 1 kilowatt. We have made them that sit in a chair that put out 11; and the 4.8-megawatt is the biggest one we have made so far and it would fit in this room, the total unit. It is quiet and there are lots of good things about fuel cells. The way we envision it working in an automobile, a long-range program would basically run at a very efficient 40 percent over a wide range and then either charge a battery, run a motor, or whatever. We use that in conjunction with storage.

Dr. MANNELLA. It would be one way of extending the basic electric vehicle's range by carrying some on-board chemical fuel which has a higher energy content.

Mr. YATES. Your latest amendment has $3 million for that. Why do you need that?

Dr. MANNELLA. To accelerate the 40-kilowatt units which would be the total energy system for the type of buildings I described earlier.

Mr. FRI. If you look at the overall energy policy, one of the things that comes out of it is that the homeowner and the apartment owner would still tend to be a user of natural gas, and natural gas is diverted to that use. Industry is discouraged from its use, so it becomes important to have a more efficient way of using that gas in the commercial and residential sector. That is what the fuel cell does.

HEAT CYCLES

Mr. YATES. You have a significant increase over 1977 in heat cycles. I think you ought to provide for the record a funding breakout and the potential savings associated with each major area identified in the budget.

[The information follows:]

DESCRIPTION AND FISCAL YEAR 1977-78 FUNDING FOR HEAT CYCLE PROJECT

[In thousands of dollars]

	1977		1978	
	Budget authority	Budget outlays	Budget authority	Budget outlays
Heat cycles:				
Components and heat engines:				
High temperature power conversion: Develop multifuel high temperature Lysholm helical expander for topping cycles	$390	$200	$1,450	$1,317
Industrial/commercial components: Develop improved efficiency components such as pumps and heat pumps for all end-use sectors	36	36	150	166
Engine components: Develop new heat engine component concepts such as small combined cycle gas turbines	0	0	300	183
Open cycle Brayton: Develop high efficiency industrial gas turbines utilizing heavy petroleum fuels	374	160	3,750	1,572
External combustion engines: Develop externally fired, multifuel, high efficiency engines (Sterling) for stationary power applications	0	49	250	134
New engine concepts: Evaluate innovative heat engines, e.g., low temperature and biphase turbine	0	5	200	158
Total components and heat engines	800	450	6,100	3,530
Heat utilization:				
Low grade heat utilization: Recover and utilize low grade waste heat (less than 200° F) primarily from uranium enrichment gaseous diffusion plants	103	60	400	200
Middle grade heat utilization: Recover and utilize waste heat (200° F to 1,000° F) by developing organic Rankine bottoming cycles for public utility diesels	700	590	2,550	2,140
High grade heat utilization: Develop topping cycles (over 1,000° F) for conventional powerplants utilizing thermionic converter devices	197	120	350	279
Cogeneration: Develop and demonstrate the cogeneration of electricity and heat with multifuel capability for industrial, commercial, and residential sites	50	30	2,400	1,141
Total heat utilization	1,050	800	5,700	3,760
Total heat cycles	1,850	1,250	11,800	7,290

HELICAL SCREW EXPANDER

Mr. YATES. Under high temperature power conversion, please explain in layman's terms what a helical screw expander is and what you expect to gain from developing it.

Dr. BELDING. The reason we went into the helical screw concept—it is just two screws that rotate—we now use them in blowing large volumes of air. The roots blower is kind of a helical screw. The reason we have gone into that, is because we think it will be a very good device for topping an existing powerplant. What we mean is we are able to run the combustion temperatures up very high. It puts out

enough power to give 10 or 15 percent above the existing powerplant.

The reason we have gone to that is because we think it will be very cost effective and also be able to handle raw coal. It turns out it is a very slow machine. It rotates very slowly, not like a gas turbine. We think that the coal going through there won't foul up the gears.

Mr. YATES. Is it a propeller?

Dr. BELDING. Not really. I guess it could be looked at that way.

Dr. MANNELLA. It is a very short helix, sort of a 3-dimensional spiral.

Dr. BELDING. We have a little plastic mock-up I can bring over and leave here.

INDUSTRY EFFORTS ON SMALL TURBINES

Mr. YATES. Would you provide for the record what industry is doing in connection with the development of small turbines.

[The information follows:]

SMALL TURBINE DEVELOPMENT

Among heat engines for the future, the Brayton cycle gas turbine has the virtue of simplicity, potentially low emissions, fuel flexibility and efficiency. Recognizing this, nine turbine manufacturers and eleven automobile manufacturers, including almost all of the majors, are active in developing their version of the automotive gas turbine. The major activity is in the U.S., West Germany, Japan and Sweden but there is also activity in Canada, Switzerland and the United Kingdom. Since gas turbine efficiency increases with temperature, many of the manufacturers are giving attention to Ceramic construction materials.

Perhaps the greatest effort has been made by Ford Motor Company under a cost sharing program with ARPA. Many of the major ceramic manufacturers in the U.S., Japan, West Germany, and U.K. are actively contributing to these efforts.

Ceramics with useful tensile strengths suitable for this application have only recently become available. They have the distinguishing characteristics of high oxidation resistence and sufficient strength at temperatures at least 500°C higher than for corresponding high temperature metals. Further, they have high hardness and also low potential cost because in many instances they are easily formed, and in the main, involve the abundant starting materials, silicon, carbon and nitrogen. Heat engines represent the application which can benefit most directly from these materials because of the higher temperature limit. Ceramics technology is in its infancy but there have been some promising demonstrations of short term serviceability of diesel and gasoline engines and gas turbines with silicon nitride and silicon carbide components.

By and large, the main emphasis, both in the U.S. and abroad, is to design and demonstrate uncooled turbine airfoils of high temperature ceramic materials. Conventional turbine design practice requires airfoils of rather thin aerodynamic shapes and these present a considerable challenge to brittle ceramic materials. In fact the desired durability has not been demonstrated to date even in a single hot rotating component test.

It is for this reason that the Division of Conservation Research and Technology initiated a project at Lawrence Livermore Laboratory to evaluate a more rugged expander design for the ceramic Brayton cycle engine. This design is known as a Lysholm helical screw expander. It produces work in a manner similar to conventional turbines by direct expansion of high temperature combustion gases.

Shaft work is produced by helical screws or rotors which are turned by the expanding gases. It differs from a conventional power turbine in that there are no thin airfoil sections susceptible to damage by contaminants in the combustion gases. The Lysholm helical expander uses only rugged, simple shapes. By virtue of simplicity and low operating stresses, the rotors of the helical screw expander could be fabricated of high temperature ceramics. Because of the superior properties of ceramics at high temperatures, it is expected that the Lysholm device could operate uncooled. Performance losses associated with cooling would be eliminated and the durability of the ceramic rotors would mean great tolerance to conditions which usually produce erosion. Thus, direct firing with coal or very low grade fuel should be possible. It is expected that, if developed in a sufficient size and used as a topping device in powerplants, the Lysholm expander will increase the overall system efficiency to 45 - 50 percent. In addition, this expander in somewhat smaller sizes would have application as a topping cycle for industrial cogeneration and total energy systems. In even smaller sizes typically around 100 to 125 horsepower, the Lysholm expander holds promise as an option for application in advanced transportation engines.

OPEN CYCLE BRAYTON PROJECTS

Mr. YATES. Under Open Cycle Brayton, you want to develop a small 10-megawatt turbine. What is the normal industrial size?

Dr. BELDING. It can go all the way up to 25 megawatts. Typically 10 is the right size. We have picked two size ranges, the 10, which we think we can scale from zero up to 25, and the other is 100, which we can scale from 100 to 150.

Mr. YATES. The 100–megawatt you speak of is a heavy fuel tolerant industrial gas turbine. Does that mean tolerant to synthetic fuels or gas from coal?

Dr. BELDING. Both. What we are trying to do is take the turbines that exist today and run on natural gas and No. 2 oil and allow them to run on heavy fuels, either residual oils or coal-derived products because we see the transition to coal products coming. It is going to take us a while to convert machinery to be able to tolerate that.

EXTERNAL COMBUSTION ENGINES

Mr. YATES. Is there a market for external combustion engines?

Dr. BELDING. Yes. We are looking at it right now, but in places like Alaska, for instance, they have lots of coal, they import their oil at $2 a gallon and they need a good machine that will allow external combustion. The problem of course is EPA. But the Stirling engine is an external engine machine.

Dr. MANNELLA. This would be stationary as opposed to the automotive.

LOW-GRADE HEAT RECOVERY

Mr. YATES. There are methods now to recover low-grade heat?

Dr. BELDING. Yes.

Mr. YATES. Can you explain that for the record? Let's put it in the record because you may want to explain it in textbook style.

[The information follows:]

LOW-GRADE HEAT RECOVERY

Domestic and low temperature industrial heat pumps are presently the primary methods for low-grade heat recovery. Efforts are underway to design and develop industrial heat pumps which are capable of increasing top temperatures to satisfy a variety of process heating needs. These efforts are aimed at selecting optimum working fluid-system component combinations that will yield the highest coefficient of performance (COP) for specific ranges of low-grade waste heat.

There are several heat engine concepts suitable for recovery of low-grade heat. These concepts are largely in the early stages of development. Simplified configurations have been tested at the laboratory to prove the physical feasibility of using such solid state working elements as Nitinol, a nickel-titanium alloy invented by the Naval Ordnance Laboratory, and selected elastomers. Much of the work yet to be accomplished includes a test of endurance, identification of appropriate design parameters relevant to the materials, and of course, the question of economics. The application of conventional methods of heat recovery for low-grade heat tends to be costly and large, considering the heat transfer and expansion/compression limitations. Therefore, the major goal to achieve for low-grade heat recovery is to develop a technology that can produce practical and economically viable systems.

MIDDLE-GRADE HEAT RECOVERY

Mr. YATES. Then we have middle-grade heat utilization. Are the currently developed systems realistic?

Dr. BELDING. There aren't currently developed systems.

Mr. YATES. What do you mean by low grade as opposed to middle grade?

Dr. BELDING. Up to 200 degrees is low grade. Between 200 and 1,000 is middle grade, and above 1,000 is high grade but it is somewhat arbitrary.

NUCLEAR WASTES

Mr. YATES. Kind of like a waste in nuclear fuel.

Dr. BELDING. Yes.

Mr. YATES. I remember the explanation given to us was there was no low-grade waste.

Mr. FRI. Our earlier discussion was on low-level waste.

Mr. YATES. Low-level waste.

Mr. FRI. Yes.

Mr. YATES. I asked the Geological Survey to explain the difference and they couldn't. They said it was arbitrary. Can you explain the difference?

Mr. FRI. Low-level waste is a common term of the nuclear business rather than a legal definition. High-level waste, however, has a specific meaning. It is generated at one step of spent fuel processing and contains much more than 99 percent of all the radioactivity in all radioactive wastes. If you never reprocess, the fuel elements themselves would be high-level waste.

Dr. MANNELLA. The technology is very different in each of the three grades. The energy content and the temperature you work with is very difficult. You need different kinds of technology.

Mr. YATES. When Geological Survey was before us they were very much concerned about the dumping areas for low-level wastes. They were concerned about the possibility of leaching and some of the wastes getting into aquifers and instreams, and so forth. They even said plutonium, perhaps as minute particles, was dumped in the low-level waste dumps.

We went into the question to some extent. I asked them about the French and the Germans, and they said the French disposed of not only their low-level wastes but high-level waste in kind of a swimming pool container about the size of this room, a concrete box kind of affair, and they just put the wastes in that; if it leaches, it leaches.

The Germans are working with salt domes. But as far as GS was concerned, they hadn't found any kind of satisfactory depository for either low level or high level waste.

Our friends who play around with nuclear power don't seem to be concerned with the disposition of waste. They say it will come in time. Yet it has been coming for 30 years, ever since 1946 when we started to use nuclear energy for nonlethal purposes; presumably nonlethal. What can you tell us about this? What are you doing about the waste problem in another subcommittee?

Mr. FRI. There are several parts to that question. First of all, the waste which by NRC's definition is not high-level waste is disposed

of in commercial burial grounds. There are about six of them around the country. These are licensed by the Nuclear Regulatory Commission or by agreement with States. A couple of those burial grounds have had problems, with activity being spread from the runoff of surface waters which had been allowed to get into unbackfilled trenches and come in contact with waste. There is one in Nevada where a guy was selling radioactive cement mixers from the site instead of actually burying them at the site. That is a problem that needs some attention, in my judgment.

The standards and the enforcement particularly against those licenses need some shining up.

The agreement States do it under NRC review, and I think the whole system has to be tightened up.

As to plutonium being dumped in the commercial burial grounds, I understand the operators themselves have stopped accepting it in anticipation of a new rulemaking. I don't think there is much, if any, commercial plutonium that got into that kind of thing, but years ago all the wastes that weren't high level, including those that contained some plutonium, were dumped into trenches on some of our sites.

There has been some migration in a few cases from those trenches, but the migration is a matter of a few feet and plutonium has a tendency to become locked in the soil by an ion exchange process.

We are having to go back in and evaluate how serious the problem is and then evaluate whether it is worth it to dig that stuff up and put it into new containers because it is very expensive to dig it up.

At present, for a number of years we have been taking the plutonium-bearing wastes and putting them in large steel drums or in boxes coated with fire-resistant fiberglass-impregnated resin, and they are stacked and covered with a waterproof material. That is pretty safe storage.

Mr. YATES. Where are those stored?

Mr. FRI. In Idaho Falls.

Mr. YATES. In what, in those boxes, in a cave?

Mr. FRI. No, on a paved pad covered by waterproofing material, plastic.

Mr. GREER. Six feet deep.

Mr. FRI. You can walk right up to those with a geiger counter and you would sense minimal levels of radioactivity because the activity from plutonium is sealed by a small cross section of heavier material. Then there is the question of high-level waste. AEC had been looking at some sites for the deposition of high-level waste for years. They tentatively chose one site in Kansas but found the site-specific questions as to the long-term integrity of the formation. There was an attempt to explore granite formations in South Carolina, and the people of South Carolina and EPA and others were very disturbed about it because there was an important aquifer under that rock and didn't want to place high-level waste in it, so the exploration was abandoned.

The question becomes, can you find a geologic formation that is likely to be stable for hundreds of thousands of years without a water intrusion? Our people believe you can find out. The prospect is that some salt formations are plastic and have the tendency to heal any cracks that might occur. We are now engaged in a very extensive

survey effort which will take a couple of years to find such formations. This year we are funded to look in 36 States, with further possibilities up to 45 States.

In most of the States we are doing the geologic literature search to see what is down there. In States where we have a lot of geologic information we are planning test drillings to characterize the nature of the underground formation.

GS is correct in saying that the right formation, the one that we really pick to do this, has not yet been found, but we are working closely with the Geologic Survey in this survey program to identify hopefully several candidate sites that would meet our requirements for permanent disposal.

Mr. YATES. I was reading a series of articles that were published in the St. Louis Post Dispatch. If my memory serves me correctly, they said the costs of storing those wastes would be in the billions of dollars.

Mr. FRI. That is correct.

Mr. YATES. It went as high as $19 billion to $20 billion.

Mr. FRI. The cost of storing the waste from commercial nuclear powerplants is much less than that.

Mr. GREER. It is in the lower $1 or $2 billion range.

ERDA DEFENSE WASTE

Mr. FRI. I will put that number in perspective in a minute. Every time you touch the nuclear business you have to add three zeros to your thinking.

ERDA has a very large volume of waste from the military programs, a much larger volume than will be produced in the commercial program, although the radioactivity is less.

Mr. YATES. The volume was about a cube the size of a football field.

Mr. FRI. The volume to the year 2000 is a cube the size of a football field and 8 or 10 feet deep. The volume from the military waste program is perhaps 10 times that, if I remember the figures correctly, and we already have most of that on hand.

Mr. MURTHA. Ten times a cube.

Mr. FRI. Ten times the cube sitting on the football field.

Mr. YATES. The size of a football field, and 8 feet deep.

Mr. FRI. There is an enormous volume of military waste that has to be handled. It is a lot more volume than the commercial waste program but lower ratio activity per unit volume. It is possible that the ultimate disposal of that military waste could be a project that runs up to $20 billion. We are now in the process of assessing all of that. The cost of the commercial waste is $1 or $2 billion, but I think it is important to understand that the commercial waste repository would cost about that much and would handle the waste from essentially all the nuclear reactors built in this country to the year 2000. That investment is what is required to support a $300 or $400 billion investment in nuclear reactors.

While it is a lot of money, it is a very small part of the total cost of operating nuclear sites.

Mr. YATES. You mean from start to finish in disposal of the waste. Where does it begin and end?

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Mr. FRI. You have to find uranium, enrich the uranium into fuel, burn it in a reactor, and then either you might reprocess it or not, depending on what we decide to do, and then dispose of the waste.

Mr. YATES. Are you charged with the $20 billion cost or the military?

Mr. FRI. It will probably be carried in our budget. That is over a 20- or 30-year period.

Mr. YATES. We still don't have a place to put the waste, do we?

Mr. FRI. We haven't yet found a place to put the commercial waste. That is the reason we are doing the broad scale survey, and we have identified a likely location in New Mexico for interment of all these barrels and boxes that I talked about in the military program, and possibly some solidified higher level waste also from the military program.

Mr. YATES. You mean like the Carlsbad Caverns?

Mr. FRI. Near Carlsbad, but in a completely different geological formation.

Mr. YATES. It's a tough problem, isn't it? Mr. Murtha?

Mr. MURTHA. Do you also have the jurisdiction for transportation of nuclear fuel?

Mr. FRI. No. For the commercial sector we do not. We transport fuel for naval reactors and other nuclear materials for ourselves.

Mr. MURTHA. In other words, if somebody buys it in a commercial plant in our area, the Navy buys it. Do you transport it through the naval facility?

Mr. FRI. If it's naval fuel, we do now or will in a short time be transferring it in our own vehicles.

Mr. MURTHA. You must now because there was some problem at one plant in our area that they felt the restrictions were so great. But I can see the need for restriction. In other words, you have a centralized transportation system. You go in and your crew handles it and transports it?

Mr. FRI. Yes; for the materials that we own. We have a fleet of special trucks that are just practically impossible to break into, a system of couriers and communication, the whole thing, and we transfer in those carriers everything from weapons and weapon components to the fuel for naval reactors and other materials that we own.

Mr. MURTHA. When you say we own, you are talking about the Government?

Mr. FRI. Yes. Actually ERDA owns essentially all of it.

Mr. YATES. Did you have a chance to comment on the St. Louis Dispatch articles?

Mr. FRI. The fellow who did those articles interviewed me for about an hour or two.

Mr. YATES. Was he accurate?

Mr. FRI. I thought his story was pretty accurate; yes.

Mr. YATES. Let's return to more mundane matters.

Thank you for your explanation. I think it's helpful. I forget who it was that appeared with Dr. Seamans last year. They kind of dismissed the waste problem, but you can't dismiss it, can you?

Mr. FRI. No; you can't. If you talk to the engineers who work in it, they will tell you that it's one of those problems that they feel is pretty clearly solvable if you just go to work on it and I think it probably is.

But we can no longer sustain a program that says we have got some smart engineers, and we will have it solved by 1985 and we will see you then.

Mr. YATES. Of course, I asked John O'Leary about this when he was before us, and he kind of dismissed it too saying we will dispose of it someplace like we have in New Mexico.

Mr. FRI. I think the most important part of our program in many respects is not the engineering mechanics going on but the fact that we have designed the program now and we do plan to have the repositories ready to go in 1985. We have established the program with two intermediate milestones, one in 1978 where we will have demonstrated a lot of prototypical piece parts, and one in 1981 when we will have gone through the NRC licensing process.

The purpose of both of those too it to present to public view in a comprehensive way the progress we have made in solving the problem. I view meeting those milestones as in some respects far more useful to the success of the program than doing the engineering, because I think the engineering is going to get done.

We have got to be able to come to the Congress and public several times before 1985 and say here's what we have done, everything works so far, we have met our milestones, and hopefully your confidence goes up by some increment because we have successfully met some interim milestone, and that is just absolutely crucial to the program.

It's easy for an engineer to be sanguine about it; it's not easy for somebody who deals with the public to be sanguine about their reaction.

THERMIONIC CONVERSION

Mr. YATES. Would you put in the record an explanation of what a thermionic conversion device is?

Dr. MANNELLA. I would be happy to, Mr. Chairman.

[The above referred to information follows:]

EXPLANATION OF A THERMIONIC DEVICE

Thermionic conversion is a method of producing electricity using a hot electrode (the "emitter") facing a cooler electrode (the "collector") inside a sealed enclosure containing electrically conducting gases. Electrons evaporated from the hot emitter flow across the interelectrode gap to the cooler collector where they condense and are returned to the emitter via the electrical load. In effect, the temperature difference between the emitter and collector drives the electrons through the load.

Thermionic energy conversion has a combination of favorable characteristics: (1) no moving parts; (2) heat rejection at relatively high temperatures; (3) lends itself to modular construction; (4) potential for efficiencies up to 40 percent; and (5) heat input in an intermediate temperature range (1200–1800 K.).

The mechanical simplicity associated with no moving parts implies reliability. The high temperature of heat rejection makes thermionic converters well suited: (1) for topping steam power plants because the heat from the collectors can be used to generate steam from conventional turbomachinery, and (2) for space application since the size and weight of the radiator are minimized. Modularity maximizes reliability for space thermionic reactors by eliminating single point system failures. In addition, modular construction results in moderate research, development and demonstration costs because most thermionic generator performance characteristics can be investigated with small units. Although thermionic efficiencies up to 20 percent have been demonstrated, much higher efficiencies are possible with reduced electrode and plasma losses. The intermediate temperatures of heat and input correspond to a range where materials and nitrogen oxide generation problems should be tractable.

Thermionic converters are not laboratory curiosities. The feasibility of thermionic conversion has been demonstrated with a variety of hydrocarbon, solar, radioisotope and reactor systems. Stable in-pile operation has been achieved for over 16,000 hours. The Soviet Union has progressed to the third generation in-core thermionic reactor with electrical outputs of over 7 kilowatts.

Fortunately, the foregoing base of high-temperature thermionic conversion technology exists. However, thermionics has yet to achieve practical application to fossil fuels because the emitter temperatures currently required for competitive power densities and efficiencies limit the operating life of the "hot shell" (that is, the protective structure which isolates the converted, per se, from the combustion atmosphere) to several hundred hours. In order to reduce the operating temperatures of converters to levels so that the hot shell will have greatly extended life while maintaining converter efficiency, it is necessary to develop improved emitter and collector surfaces as well as decrease the plasma losses occurring as the electrons flow across the interelectrode space. Most of the papers in the thermionics session address these electrode and plasma loss problems. Moderate progress has been made in both areas. As converter performance improves, subsequent engineering development of the following applications should become feasible: (1) solar-thermal-electric powerplants; (2) radioisotope thermionic generators, (3) Out-of-core space reactors; (4) hydrocarbon auxiliary power units; and (5) Thermionic topped fossil fuel powerplants.

COGENERATION

Mr. YATES. Also put an explanation of cogeneration in the record.

Dr. MANNELLA. Yes, sir.

Mr. YATES. Also how it differs from your community systems program.

Dr. MANNELLA. I would be happy to.

[The information follows:]

Co-Generation Of Electric Power In Conjuction With Industrial Process Steam

It has been recognized for sometime that electricity and steam can be generated together in the same power plant more efficiently than they can be generated in separate power plants.

In a central station fossil fuel-fired steam power plant, approximately one-third of the energy of the fuel is converted into electricity and two-thirds escapes in the form of thermal discharges. Most of the discharge results from the condensation of steam and the subsequent rejection of this heat to bodies of water or the atmosphere. Such facilities are optimized for the production of electricity and thus the reject heat is at very low temperature and not suitable for process heat requirements.

The concept of co-generation involves producing both electricity and process heat on the industrial or residential site. It is not feasible to utilize central station type systems directly for co-generation since the rejected thermal energy is not at a sufficient temperature to be transported or used effectively. However, there are several options available for dispersed industrial co-generation systems. A different type of steam system involving a back pressure turbine would produce electricity at relatively low efficiency (10-20% as opposed to about 38% in a central plant) but process steam temperatures of 400-600° F can be readily achieved. Gas turbine or diesel engine topping cycles with a steam generator in the exhaust are other alternatives which can offer both higher efficiencies and acceptable steam conditions. Currently available gas turbines and diesels offer comparable electrical conversion efficiency levels in the 25 to 28% range. The gas turbine is more suitable for larger co-generation installations of about 10MW and above whereas diesels favor the lower capacity level. Both engines now require relatively clean gaseous or liquid petroleum derived fuels with the gas turbine being capable of using a somewhat broader quality range. However, technological advances from ERDA research efforts can be expected to widen the acceptable fuel characteristics of both engines in the future years. These research activities should lead to an ability to effectively utilize low grade petroleum such as residual oil and minimally processed Syn fuels when they become available in sufficient quantities.

Also, new technology such as advanced high temperature topping cycle expansion devices, fuel cells, and external combustion heat engines can be expected to replace or supplement gas turbines and diesels beyond 1985. These devices, although in very early stages of development, are designed to operate on virtually any fuel. If the technology is proven successful, electrical conversion efficiencies approaching 40% could be attained with low grade residual petroleum, fuel from waste products, and direct coal firing.

Co-generation of industrial process steam serves as the sink for the power cycle, decreasing thermal discharge substantially. The effective efficiency of the industrial power plant generating steam and electricity together ranges between 60 and 75 percent, whereas the electrical conversion efficiency of a central station steam power plant today is at most 38 percent. Fuel savings estimated for the use of co-generation in three of our energy intensive industries, petroleum, paper and chemicals, exceed 500,000 equivalent barrels of oil per day.

COGENERATION

Mr. YATES. Is cogeneration a common practice in Europe?

Dr. MANNELLA. Much more common that it is in the United States.

Mr. FRI. About 4 percent of our electrical power is now generated in that fashion.

Mr. YATES. What else do we need to implement this technology?

Dr. MANNELLA. I think we have to show in specific situations what the economics are. You have to match the electrical load for the use for the waste heat or steam that you produce.

WASTE HEAT UTILIZATION

Mr. YATES. You have asked for an additional $2 million for waste treatment.

Dr. MANNELLA. That is correct. That is from the ERDA gaseous diffusion facilities and the facility in South Carolina.

COMBUSTION TECHNOLOGY

Mr. YATES. Let's talk about combustion for a minute.

In view of the fact that the auto industry needs to meet increased mileage standards, are you doing anything in this area?

Mr. BELDING. Our No. 1 priority in the combustion program is, in fact, the internal combustion engine. We are not working on engines per se, but we are trying to understand the combustion process. It's kind of a long range, high-risk program, but if we understand it, it can be implemented immediately out in industry, and we have several agreements with General Motors, Ford, Chrysler in the combustion program.

Mr. YATES. Have the foreign manufactures liked this to a greater extent than our domestic manufacturers have?

Dr. BELDING. Not really. It turns out the foreign manufacturers are using the stratified charge engine in the Honda. However, they don't really understand the combustion process either. We have sent people from the lab all over the world. As a matter of fact, I had one of my people go over to Europe a couple of weeks ago to take a look at the German efforts, which are far advanced over ours.

They still are putting a heavy emphasis on combustion and they are looking forward to an agreement we have now with them in the IEA.

Mr. FRI. It is extraordinary that for as long as the world has been burning material we know as little as we do about what goes on in the actual combustion process. That turns out to be practically a new field and it's just extraordinary.

Dr. BELDING. With the advent of the high powered lasers and big computers, we can now almost handle combustion. It turns out that Lawrence Livermore has developed hydrodynamic codes over the last number of years for weapons programs. They have the largest computer in the world and it takes a couple of hours to run one of their hydro codes. The hydro part of the combustion is only a very small part of it, so we are still having a hard time getting it into a tractable position so we can handle it in the computer. We don't understand it experimentally.

ALTERNATIVE FUELS TECHNOLOGY

Mr. YATES. You talk about developing technology for alternate fuel for gas turbine combusters, boilers and furnace burners, industrial process burners, alternate fuels technology. Shouldn't this be in the fossil energy area?

Dr. BELDING. Not really. The reason we are trying to understand it in conservation is because we feel the equipment that is currently used is going to have to be fuel converted or the new equipment is going to have to be built so it will handle multiple fuels.

The fossil people are primarily interested in the process of going from coal to coal oil, and what we are attempting to do, in conjunction with them, is to understand how it affects the equipment that is presently in the field and will have to be put out in the future.

METHANE FROM COAL BEDS

Mr. YATES. But they are working on conversion of methane from coal, and you want $500,000 for the same process.

Dr. BELDING. I don't think so. Methane from coalbeds;is that what you are referring to?

Mr. YATES. Page 97, coalbed methane conversion.

Dr. BELDING. Right. Conversion.

Mr. YATES. Conversion.

Dr. MANNELLA. As Dr. White mentioned yesterday, that is a cooperative program with fossil conservation and the Bureau of Mines.

Mr. YATES. So you have a troika on this.

Dr. MANNELLA. Yes; and we are concentrating on utilization.

Mr. YATES. The Bureau of Mines is also in the field?

Dr. MANNELLA. That is right.

Mr. YATES. So it's a quartet.

Dr. MANNELLA. No, sir, the program only involves ERDA's fossil and conservation programs and BOM.

Mr. YATES. You, fossil, and the Bureau of Mines.

Dr. MANNELLA. Yes.

Mr. BELDING. I can submit a one-page summary of what the various responsibilities are.

Mr. YATES. OK, that would be helpful.

[The information follows:]

COORDINATION OF METHANE FROM COALBEDS PROGRAMS BETWEEN ERDA AND BUREAU OF MINES

The fundamental differences between the ERDA program and the Bureau's are easily identified at a programmatic level. There are two aspects of the ERDA work which distinguish it from the Bureau's. One is that ERDA's work treats methane from coalbeds as yet another nonconventional source of gas and concentrates largely on the extraction of methane from coalbeds which are not likely to be mined in the near future, for example, from western coals under more than 3,000 feet of cover. The second is the heavy emphasis given to the utilization of methane in the ERDA program, for example, the use of methane in fuel cells or for use in turbines.

The Bureau's program focuses on the extraction of methane much closer to the mining process. Generally the Bureau's research goals relate to the removal or control of the methane for mine safety reasons per se and/or the economic extraction of methane from the mine workings or from the coalbeds prior to mining to improve the efficiency of the mining operation.

Both agencies have the responsibility for developing the technology necessary for their particular areas of interest. ERDA's technologic development effort is concentrated principally in the utilization area with some effort in the field of drilling and stimulation of gas flows. The Bureau's work concentrates on drilling and the techniques for gas removal from mining areas.

While there are possibilities for duplication of work where the areas of interest overlap, the probability of this occurring is minimized by continuing discussions between the respective program offices on the future project-level activities of the two agencies. In addition the agreement between ERDA and the Department of the Interior provides an additional, more formalized method for assuring coordination of work.

SUPPORTING TECHNOLOGIES FOR END-USE APPLICATIONS

Mr. YATES. Now we turn to supporting technologies for end-use applications. What is the relationship of materials and fabrication technology to ERDA's overall materials program?

Mr. BELDING. In many of the supporting technology areas we have several divisions within ERDA doing the same kinds of work.

Mr. YATES. Fossil energy is doing it too?

Mr. BELDING. Yes; we have sent out a letter and it's joined by four assistant administrators. Basically what it says is that we will form committees on materials, combustion, et cetera, so that we can coordinate internally. We have rotating chairs, and this quarter we are in charge of the combustion group. There are three people involved in that within ERDA. It has been working very effectively, and we have a similar one in materials. In fact, we have one in materials that cuts across the whole Federal Government, and we have laid out a plan of what needs to be done in materials.

Mr. YATES. Would you put in the record a funding breakout for the categories that you list in this area?

Dr. MANNELLA. Be happy to.

[The information follows:]

FY 1977/87 FUNDING BREAKOUT FOR IMPROVED CONVERSION EFFICIENCY

IMPROVED CONVERSION EFFICIENCY	FY 1977 BA	FY 1977 BO	FY 1978 BA	FY 1978 BO
A. FUEL CELLS				
Utility Demonstrations	13,500	7,310	16,500	15,568
First Generation Technology	0	0	900	660
Second Generation Technology	1,200	640	2,200	1,660
Fuels Utilization	250	120	900	805
Systems Development	2,250	893	6,400	6,662
Applied Research	1,800	487	1,300	1,545
Total Fuel Cells	19,000	9,450	28,200	26,900
B. HEAT CYCLES				
Components and Heat Engines				
High Temperature Power Conversion	390	200	1,450	1,317
Industrial/Commercial Components	36	36	150	166
Engine Components	0	0	300	183
Open Cycle Brayton	374	160	3,750	1,572
External Combustion Engines	0	49	250	134
New Engine Concepts	0	5	200	158
Total Components and Heat Engines	800	450	6,100	3,530
Heat Utilization				
Low Grade Heat Utilization	103	60	400	200
Middle Grade Heat Utilization	700	590	2,550	2,140
High Grade Heat Utilization	197	120	350	279
Cogeneration	50	30	2,400	1,141
Total Heat Utilization	1,050	800	5,700	3,760
Total Heat Cycles	1,850	1,250	11,800	7,290
C. COMBUSTION				
Internal Combustion Engine Combustion Components	400	310	1,900	1,609
Gas Turbine Combustors	230	195	300	302
Boiler and Furnace Burners	120	25	450	373
Industrial Process Burners	0	0	50	37
Alternate Fuels Technology	100	50	1,400	1,132
Fuel Processing, Transport and Storage Technology	0	0	100	75
Coalbed Methane Conservation	0	0	3,000	2,432
Total Combustion	850	580	7,200	5,960
D. SUPPORTING TECHNOLOGIES FOR END USE APPLICATIONS				
Thermodynamics and Heat Transfer	300	250	2,000	1,340
Materials and Fabrication Technology	689	550	2,000	1,350
Controls and Process Efficiency	250	170	2,000	1,100
Planning and Analysis	211	200	2,000	1,260
Total Supporting Technologies for End Use Applications	1,450	1,170	8,000	5,050
Total Improved Conversion Efficiency	23,150	12,450	55,200	45,200

ENERGY EXTENSION SERVICE

Mr. YATES. Energy extension. How do you avoid duplication with the extensive State and local programs in FEA in this? Can you put that in the record?

Dr. MANNELLA. Yes.

[The information follows:]

ENERGY EXTENSION SERVICE

Actions taken by ERDA to avoid Duplication with FEA and Individual State Activities

To ensure that Energy Extension Service (EES) activities do not duplicate, but rather supplement, other similiar activities, ERDA has taken two actions. First, ERDA and FEA have co-signed an agreement (see attached) regarding mechanisms to coordinate the EES with the FEA State Energy Conservation Program. These coordination mechanisms include:

- FEA staff assistance in preparation of the competitive State solicitation for the EES initial program
- FEA staff participation in the EES initial program State selection process
- ERDA staff participation in the FEA overview of State Energy Conservation Plans and Supplemental State Energy Conservation Plans

Second, ERDA requires a number of state certifications regarding non-duplication of effort in the competitive solicitation for the initial program. In particular, States are asked to certify that:

- the proposed EES funding will not replace or supplement funding from other sources (such as Federal, state or local governments, and private organizations) now provided for similiar activities, but rather supplment such funds.
- none of the proposed EES activities are being funded or accepted for funding by another Federal agency
- none of the proposed EES activities has been proposed for funding to FEA under the State Energy Conservation Program. (If the State cannot certify to this statement, the State is required to list all such proposed activities. ERDA and FEA, working through their coordination mechanisms, will insure that there is no duplication of fudning for these activities.)

FEDERAL ENERGY ADMINISTRATION
WASHINGTON, D.C. 20461

22 APR 1977

MEMORANDUM FOR THE FILES

FROM: RICHARD N. VANNOY
ACTING ASSOCIATE ASSISTANT ADMINISTRATOR
STATE ENERGY CONSERVATION PROGRAMS

JUDITH M. LIERSCH
DIRECTOR, OFFICE OF INDUSTRY RELATIONS
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATON

SUBJECT: COORDINATION BETWEEN THE STATE ENERGY CONSERVATION PROGRAM AND THE ENERGY EXTENSION SERVICE PILOT PROGRAM

To facilitate coordination between the management of the State Energy Conservation Program (SECP) and the Energy Extension Pilot Program, the two organizations administering the programs have agreed to undertake a number of joint efforts. The purpose will be to insure overall coordination of programs and non-duplication of efforts by means of frequent and open communication, exchange of program documents and information, and participation in the program review and selection procedures of each agency.

The Energy Extension Service (EES) is designed to encourage small energy users within the State to adopt measures which save energy or utilize renewable energy sources, by providing on a personalized basis, information and assistance regarding the availability, technical details, and energy and cost savings potential of energy efficient techniques. Services offered would vary by State and locality to fit the specific interests and needs of the consumers. ERDA is currently proceeding to implement a two-year pilot extension service program involving approximately 10 States to be selected competitively. The objectives of the pilot program are to:

- Test the overall concept of providing personalized information and assistance on energy conservation measures and renewable energy sources to small energy consumers and to the organizations that influence their energy consumption.

- Determine the most effective methods of designing and operating State energy extension services.

- Determine within the context of State Energy Extension Services, the most effective ways of (1) obtaining feedback on the energy consumer's technology needs at the local level to be factored into the Federal research and development (R&D) program and (2) identifying institutional barriers to the adoption of energy measures by small energy consumers.

After 2 years of State service operations or earlier, if warranted, the Administrator will make recommendations to the President and Congress regarding continuation or modification of the pilot program and nationwide implementation of the EES.

FEA, under authorities provided by the Energy Policy and Conservation Act (Public Law 94-163) and the Energy Conservation and Production Act (Public Law 94-385), is implementing programs to promote energy conservation in the States. The base program established by Public Law 94-163 requires that participating States prepare comprehensive energy conservation plans designed to reduce projected energy consumption by 5 percent in 1980, and address five specific program measures in order to be eligible for funding: (1) mandatory lighting efficiency standards for non-Federal public buildings; (2) programs to promote the availability and use of carpools, vanpools, and public transportation; (3) mandatory State procurement policies relating to energy efficiency; (4) mandatory thermal efficiency standards for new and renovated non-Federal buildings; and (5) right-turn-on-red. States may also include in their plans any other appropriate program measures that conserve energy or improve efficiency in the use of energy.

In order to qualify for funding under the supplemental program established by Public Law 94-385, a State must address procedures for: (1) carrying out a continuing public education effort on implementing energy conservation measures; (2) insuring effective intergovernmental coordination; and (3) encouraging and carrying out energy audits for buildings and industrial plants. The States also have the option of including additional program measures in their supplemental plans.

Both the ERDA Energy Extension Service and the FEA State program use Federal Government resources to promote energy conservation in the States. Encouraging consumers to conserve energy is a larger endeavor than either program alone can adequately address. In combination the task becomes more manageable.

With careful planning and management, the staffs of the two programs can ensure that their respective programs complement and supplement each other, rather than duplicate activities. In addition, coordination between the two programs is necessary in order to:

- Optimize the use of Federal resources.
- Provide a clear delineation of responsibilities for the benefit of the States which will be the participants in the two programs.
- Simplify program management for the States by establishing consistent administrative requirements whenever possible.
- Enhance the effectiveness of both efforts. For example, the techniques for information dissemination tested through the EES can be used to improve the delivery mechanisms of the SECP.

At this time, the following have been defined as specific ways in which the staffs of the two programs will cooperate:

ERDA Staff Participation in the FEA Overview of State Energy Conservation Plans

ERDA will participate in the national FEA Office of State Financial Assistance (OSFA) overview of State energy conservation plans. While the FEA Regional Offices are responsible for final review and approval of State plans, the OSFA will assist the regions by analyzing each plan's environmental assessment and by offering assistance of a technical nature. The OSFA will also review each plan for major deviations from national energy policy and for overlap with other Federal programs. ERDA will receive, as background information, summaries of each plan prepared by the OSFA staff. ERDA may offer suggestions on each program measure as appropriate and may be called upon to answer technical questions. This overview process will begin the last week in March and continue into June 1977.

FEA Staff Assistance in Preparation of the Program Research and Development Announcement (PRDA)

FEA has reviewed and commmented on the PRDA content and has helped ERDA draft various sections. A major emphasis during this phase has been placed on eliminating or minimizing all possible duplication and in helping ERDA to utilize, wherever possible, the reporting and other administrative requirements adopted by FEA to simplify what States have to do. For this task, the OSFA is providing the services of several staff members on a part-time basis to work directly with ERDA.

FEA Staff Participation in ERDA's State Selection Process

FEA expects to contribute in two ways to the ERDA review of the State proposals. First, FEA will confirm that States are not proposing to ERDA specific activities already funded or accepted for funding by FEA under SECP. FEA will also confirm whether the State has proposed activities for funding to ERDA under the EES that are the same as those proposed under SECP, but that have not yet been approved for FEA funding. In cases where a State proposes the same activity for funding to the two agencies and the State is selected for the EES pilot program, the State may submit a modification to FEA to undertake different activities under the SECP. ERDA and FEA will coordinate closely during the EES selection process to ensure that duplicate funding is not provided.

Second, FEA representatives will participate in the two-step review and selection process for the State proposals. One person will serve as an advisor to the ERDA Technical Review Committee to answer questions on apparent similarities in program content between proposals submitted for ERDA funding and State energy conservation plans. A second person will sit on ERDA's Source Selection Panel which will make the final selection of States to receive grants for an EES. ERDA will thus be able to draw on FEA's knowledge about the States' plans in order to ensure complementary rather than duplicative programs funded by the two agencies. The review and selection process for the EES is expected to be completed by the end of July 1977.

ERDA Staff Participation in FEA Overview of the Supplemental State Energy Conservation Plans

It is anticipated that ERDA's participation in the national FEA overview of the supplemental State plans will be similar to its role during the overview of the basic State plans. The purpose at that time will be to ensure that the States awarded grants for extension services have not requested FEA funds for duplicate activities as part of their supplemental plans. Overview of the supplemental plans will occur between mid-August and September 30, 1977.

In addition to cooperating in the ways described above, the two agencies will define further areas of cooperation as their respective programs progress.

Mr. YATES. You are having trouble with this, aren't you? We had trouble with you and FEA on this before. We felt that over the last several years this was a duplicative program and we still feel that. But we will let you try to tell us in what ways you are different.

How do you plan to implement it? Put that in the record too.

Dr. MANNELLA. Yes, sir.

[The information follows:]

PLANS FOR IMPLEMENTING THE ENERGY EXTENSION SERVICE

In conformance with the legislation presently under consideration, ERDA is implementing the EES on an initial basis. The initial program will involve approximately ten States to be selected competitively. The competitive State solicitation, issued on April 29, was prepared with input from the National Governor's Conference and from FEA. Attached is the ERDA milestone chart for EES implementation.

State EES proposals in response to the solicitation will be submitted by June 30. ERDA anticipates that winning states will be awarded funds in mid-August, with detailed implementation planning and state operations to follow thereafter.

The initial EES program is desinged to provide information which will be of use in structuring a nationwide EES program. In particular, the initial program has three major objectives:

- To test the effectiveness of encouraging the adoption of energy conservation opportunities and renewable fuel technologies by means of providing assistance and information on a local and personalized basis to small energy consumers;

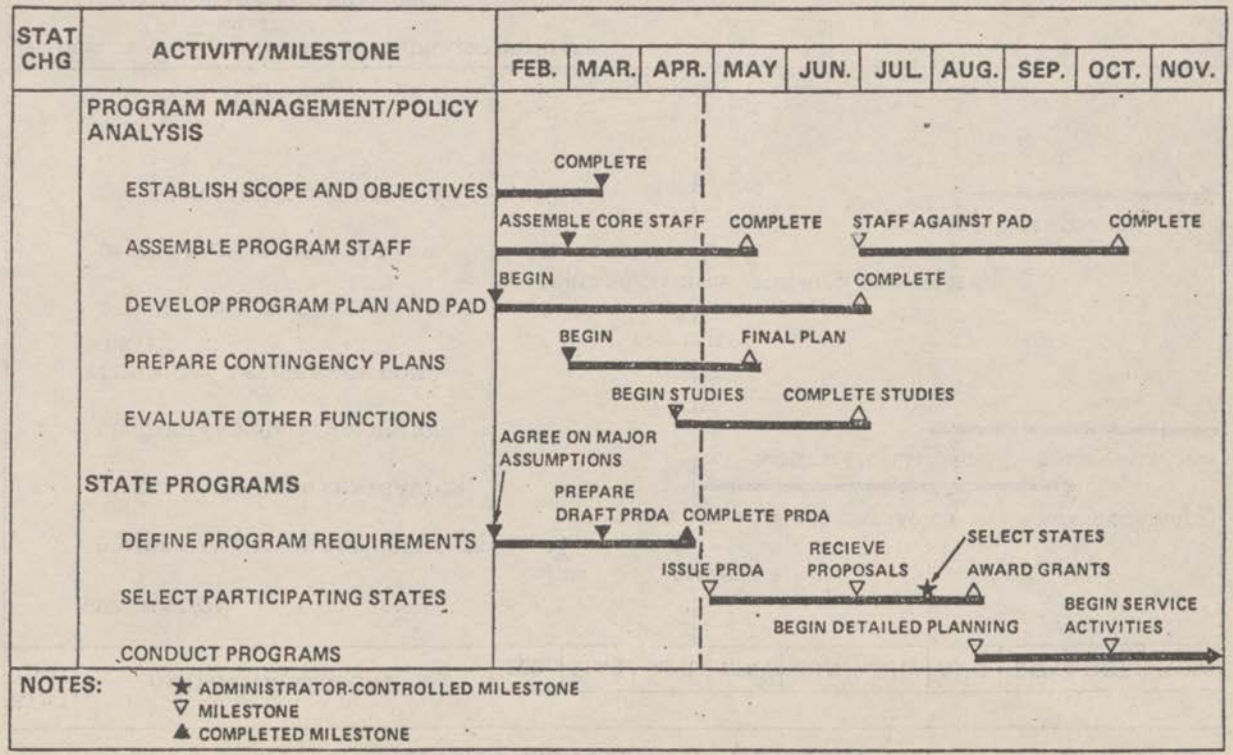
- To determine the most effective methods of designing and operating State EES programs; and

- To determine, within the context of the State EES programs, the most effective ways of (1) identifying insitutional barriers to the adoption of energy-saving measures, (2) identifying issues associated with consumer acceptance of such measures, and (3) obtaining feedback on consumer research and development needs to be factored into energy research and development programs.

Intensive evaluation of the initial program results is a high ERDA priority, with evaluation forming an integral program component from the beginning of state operations. ERDA will engage contractor assistance for the design of monitoring and evaluation systems and for the conduct of the evaluation process. In addition, every effort will be made to assure that the lessons learned during the pilot program will benefit non-participating as well as participating States. Selected States will assist in sharing the results of their EES activities with the other States during the course of the pilot program, and ERDA also will undertake activities in this regard.

ENERGY EXTENSION SERVICE

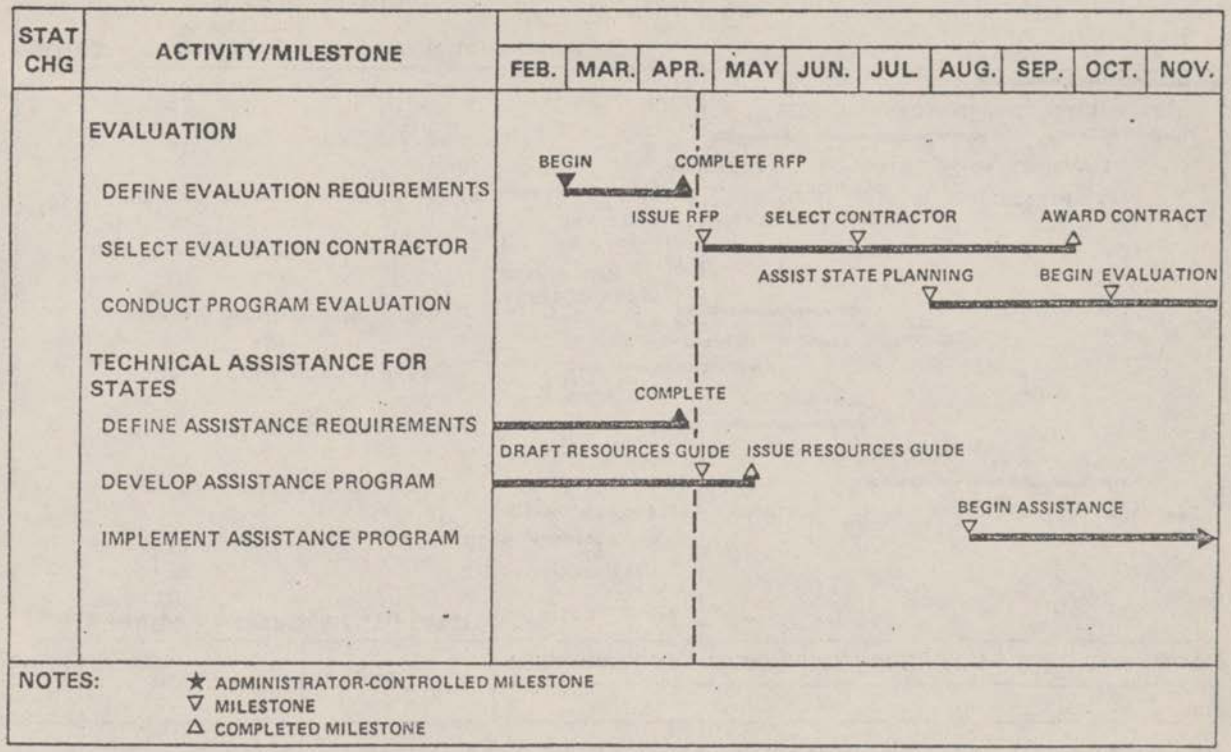
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ENERGY EXTENSION SERVICE

APRIL 27, 1977



77-2686/6-11

FUNDING OF ENERGY EXTENSION SERVICE

Mr. YATES. How do you propose to fund it, on a formula basis?

Dr. MANNELLA. I would like to ask Judy Liersch to respond.

Mr. YATES. All right, Ms. Liersch.

Ms. LIERSCH. The pilot portion of the program which is scheduled for 2 years will not be funded on a formula basis. In the selection procedure that we have under way now, we are asking the States to come in and tell us what they need in order to reach the proposed target audience.

Mr. YATES. You hope for innovative proposals, I suppose. Is 2 years a sufficient period for a pilot program?

Ms. LIERSCH. I would say so; yes.

Mr. YATES. You commissioned a contract with EDUCOM on technology transfer programs and they prepared a report and they recommended a minimum of 3 years. You don't agree with them, obviously?

Ms. LIERSCH. No, I don't.

Mr. YATES. OK. I take it you are more expert than they are in the field.

They recommend incentive funds for high risk or long term programs. Do you approve of that?

Ms. LIERSCH. Yes, I do.

Mr. YATES. They recommend a program that is administered in a division with an operational mission, preferably conservation.

Ms. LIERSCH. I believe that recommendation is made in the context of full nationwide program, should that in fact be legislated, and should the results of our pilot program show that would be a wise course of action.

Mr. YATES. You are going to establish it as a staff function?

Ms. LIERSCH. It's presumably going to be an organizational entity in the Department of Energy after the pilot program, and where it ends up has not been specified in the present plans.

Mr. FRI. I elected to run the pilot program out of our staff office that Judy represents for a whole host of reasons.

I think an operational program in the context of a new Department of Energy would probably have to go someplace else.

Mr. YATES. OK.

FUNDING OF ENERGY INVENTIONS PROGRAM

Mr. Greer has information on how to handle funds for energy inventions.

Mr. GREER. Mr. Chairman, there are a couple of different options. Energy invention activities involve programs under both this subcommittee and the Public Works Appropriations Subcommittee. In addition the NBS evaluation program is funded under the Public Works Subcommittee in the program support line. We could add another line specifically for inventions assistance in our program support category that is under this subcommittee's cognizance.

Alternatively, we could include a line item in one of the programs under this subcommittee's cognizance. Our recommendation to you would be to continue to use program funds set aside for the use of the energy related inventions program. We would identify these funds

to you, and your report could take into account the amounts set aside for that program.

We would recommend approximately $1.6 million for fiscal year 1978, covering some 60 inventions at a little over $25,000 each. That could also be identified in the report, if you decided to do that.

Mr. YATES. OK, that's fine.

We have come to the end.

Dr. Long has some questions here that he wants answered. They may be answered for the record.

[Mr. Long's questions and ERDA's answers follow:]

Question. The fiscal year 1977 ERDA authorization included a program for appropriate technology. The Interior Subcommittee of the Appropriations Committee in its fiscal year 1977 report also endorsed such a program, and stated that the Congress believes that intermediate technology should be encouraged. In addition, the President in his recent energy message announced his intention to create an Office of Appropriate Technology.

Despite these clear statements of intention by the legislative and executive branches, ERDA has yet to spcifically budget funds for an appropriate technology program. Why has there been a delay?

Answer. We recognize that the Congress has endorsed the appropriate technology program through inclusion in the fiscal year 1977 ERDA authorization. The President in his April 20 message to Congress has proposed the establishment of an Office of Small Scale Technology in order to tap more fully the great potential of the Nation's individual inventions and small business firms. As a result of that and other actions, we are developing plans for implementing an appropriate technology program.

We believe that there is a great potential for meeting our energy objectives through a number of different approaches and appropriate technology certainly seems to be one means of achieving that goal.

We have not specifically projected funds for appropriate technology as a separate line item because we believe that this program could be funded in the programmatic divisions as part of their program thrusts. We are also waiting until we get reactions from the appropriate technology community and other Federal agencies to our proposed plan prior to commencing the program.

Question. When does ERDA expect to have a specific budget ready for an appropriate technology program?

Answer. As I stated earlier, we will be looking to the programmatic divisions who have an interest and stake in appropriate technology to fund this program.

Question. The fiscal year 1977 authorization would have mandated $7,500,000 for a small grant program in appropriate technology. Does ERDA think this a reasonable sum for such a program? How much money does ERDA plan to spend on this program in fiscal year 1978?

Answer. The appropriate technology program envisioned will be a program of small grants, agreements or contracts for development of energy related appropriate technology. The program will be receptive to a broad range of appropriate technology projects from the "small ideas" of entrepreneurs to the testing of products and processes and the full scale demonstration of more advanced concepts. Funding for projects under the program may be made to individuals, local nonprofit organizations and small businesses.

Appropriate technology, as being developed by ERDA, can be defined in terms of resources, scale and efficiency and end uses as follows:

In terms of resources, appropriate technology:

Relies upon renewable energy sources rather than fossil fuels and uranium;
Is labor—rather than capital—intensive;
Is compatible with local labor skills; and
Utilizes locally available materials.

In terms of scale and efficiency, appropriate technology:

Is efficient in its use of energy and other inputs;
Provides opportunities for technology transfer;
Is simple to install;
May employ scaled down industrial technology; and
Emphasizes the application of existing technologies for novel situations.

In relation to the end-user, appropriate technology:

Satisfies demonstrated local need;

Decreases community dependence on external sources of energy and power resources;

Is environmentally sound;

Results in durable systems and/or products.

Projects will fall within three categories. The first one, idea development projects, which will consist of grants or contracts of $10,000 or less to demonstrate the potential of an idea that has not yet been developed into a fully matured project. In general, these grants or contracts will be limited to 1 year. The second category consists of concept testing and demonstration projects. These will be larger grants or contracts for projects that have gone beyond the initial development stage and have designed a tool, approach, or technology that merits testing under laboratory or field conditions. The third category will be programmatic thrust projects, which will consist of projects in a specific area which ERDA Headquarters has designated as an area of focus for a specific fiscal year; for example, low technology, cheap home conditioning devices, devices for irrigation pumping, use of small scale waste utilization devices, and so forth.

The largest grant or contract to be $50,000 over life of project as a result of this program. If the project warrants further support, it would have to compete with other ERDA programmatic thrusts.

We believe that various levels of funding could be appropriated for the proposed program. ERDA is currently evaluating three alternate levels.

(a) $1 million per year would establish a pilot program in one Federal region, with 30 percent of funds for programmatic thrust projects and 70 percent of projects for category 1 and 2 projects.

(b) $5 million per year would establish a larger pilot program in 4 regions including all thrusts as described above.

(c) $18 million per year would establish a nationwide appropriate technology program in 10 regions including all thrusts as described above.

Question. What percentage of the funds in such a program would be used for administrative costs? What percentage for actual small grants?

Answer. Administrative costs will range between 5 to 10 percent of funds available. Small grants will range between 90 to 95 percent. Since these projects will differ from those currently funded within ERDA, we are not positive about the accuracy of our administrative cost estimates. A pilot program would allow us to determine the actual administrative costs. We do not know how many proposals would actually be received, the costs of evaluation and selection of the proposals, and monitoring of the projects.

Question. Does ERDA plan to seek the expertise of the National Center for Appropriate Technology (NCAT), funded by the Community Services Administration, to aid in administration of small grants program?

Answer. Yes; we have been in contact with the NCAT as well as the California State Office of Appropriate Technology. Good dialog has been initiated and we fully expect that we will be partners in this effort with their organizations as well as other appropriate technology organizations.

Question. How does ERDA plan to disseminate the technologies that will be generated by the grant program, considering that many of the target communities in such a program will be outside the mainstream of technological communications? Will the National Center for Appropriate Technology be brought into this phase of the program?

Answer. We plan to use fully, all available communication channels. The Energy Extension Service and the Department of Agriculture's Cooperative Extension Service will be used extensively to disseminate the information. The National Center for Appropriate Technology (NCAT) has indicated a willingness to help us in a dissemination effort. Discussions with the NCAT indicate that we can use their magazine for information dissemination. Other appropriate technology publications will also be used for publicizing the available technologies.

Question. Will someone from the appropriate technology program in ERDA be part of the tripartite working group set up by ERDA, AID, and State to bring new energy technologies to the developing countries? Wouldn't this be appropriate given the situation of capital scarcity and abundance of labor that is characteristic of less developed countries?

Answer. Yes; this program dovetails nicely with the ERDA, lesser developed countries (LDC) program in that similar technologies may be applicable in both the United States and developing countries. Together these programs will be more effective than each would be separately.

We have been working with AID and the Department of State in the development of the program for LDC's.

We will be establishing an informal interagency committee to coordinate Federal efforts in the appropriate technology area. Membership will consist of, but not be limited to, ERDA. Community Services Administration, Agency for International Development, National Science Foundation, Small Business Administration, Office of Technology Assessment, Department of Commerce, Federal Energy Administration, and Environmental Protection Agency.

CONCLUSION

Mr. YATES. Dr. Fri, any trouble spots we ought to know about? Is there any way we can help you over any of your problems you haven't told us about yet?

I know you have had lots of them, including the fact you don't know whether you are an administrator or not and you don't have any administrator, but you are waiting for the new Department of Energy reorganization; aren't you?

Mr. FRI. Yes.

Mr. YATES. OK. In the meantime how can we help you? Anything you haven't told us that you think you ought to tell us?

Mr. FRI. I am sure we will find something as we go on. But I can't think of anything.

Mr. YATES. Embellish your statement for the record if you want to.

In the meantime, thank you very much. You have been very helpful, and I hope we do well by you. We will try to.

Mr. FRI. If you can be of any more help we will let you know.

Mr. YATES. Thank you very much.

Mr. FRI. Thank you, Mr. Chairman.

WEDNESDAY, APRIL 27, 1977.

MHD

WITNESSES

HON. ALBERT J. GORE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TENNESSEE

JOHN B. DICKS, DIRECTOR, ENERGY CONVERSION DIVISION, UNIVERSITY OF TENNESSEE SPACE INSTITUTE

Mr. YATES. Mr. Gore, we are glad to have you.

I knew your father very well. He was a good friend of mine years and years ago. How is he, all right?

Mr. GORE. Fine. He is in good health and working hard.

Mr. YATES. All right.

You are here on behalf of MHD and your statement may be made part of the record.

[Mr. Gore's statement follows:]

STATEMENT OF CONGRESSMAN ALBERT GORE, JR., BEFORE INTERIOR APPROPRIATIONS SUBCOMMITTEE, APRIL 27, 1977

Mr. Chairman, and members of the subcommittee, I appreciate this opportunity to present for your consideration my views about the budget for the Energy

Research and Development Administration (ERDA) for fiscal year 1978. I want to direct my remarks to the national magnetohydrodynamics (MHD) program. This program offers the potential for cleaner and more efficient production of electricity by the use of coal than is possible with existing technologies. I want to respectfully request that you insure adequate funding for the overall MHD program, including especially the pioneer project located at the University of Tennessee in Tullahoma.

The University of Tennessee has been producing MHD power from eastern (high-sulfur) coal in its Tullahoma installation for the past 4 years. This installation is unique in the world, and it should be emphasized that it is the only one being operated exclusively on coal.

The present coal flow rates are high, varying from 1 to 2 tons of coal feed per hour. The plant is relatively complete and demonstrates not only the production power but also the complete removal of sulfur from coal at low cost.

A successful MHD program will require the direct production of electrical power, development of pollution controls, economic recovery of potassium, and construction and testing of high temperature steam boilers, slag separators, and the other components unique to MHD which are needed for a full-scale powerplant. The University of Tennessee MHD installation is the only place where all of these developments are taking place. Daily operation of existing equipment is leading to solutions for the problems encountered in the advancement of MHD technology.

The installation is presently under contract to ERDA to move to development of a larger prototype. The scientists and engineers in charge have designed a plant with coal flow rates of between 1 to 10 tons per hour. This plant will be capable of continuous feed of eastern coal at the lower rate and inexpensive expansion to the higher rate as a later possibility. This facility is to be complete, containing pollution control equipment, sulfur removal, and downstream boilers. ERDA has approved the design of most of the critical facility equipment, and all of it is on order. Experimental equipment is all based on prototypes already successfully operated in the existing laboratory and is, therefore, expected to work with a high degree of reliability.

I believe it is fair to say that without the 14 years of effort at the University of Tennessee and its unique demonstration of MHD power from coal, there would not now be a substantial MHD program in the United States. Furthermore, I believe that the success of all other MHD programs depends upon completion of the developments underway at the Tennessee facility.

Unfortunately, despite all the essential work at the University of Tennessee, this vital program faces the prospect of being delayed. It faces serious funding problems in fiscal year 1978.

The current budget request for MHD is $50 million. However, $28 million of that amount is slated for the component development and integration facility (CDIF) in Montana and a substantial amount has been earmarked for the Soviet Union's program. Yet the very low minimum needs of $4.2 million required by the University of Tennessee may not be met unless this subcommittee takes action.

The Subcommittee on Fossil Fuels and Nuclear Energy considered the MHD program last month and voted to increase its budget by $17.6 million, with $15 million earmarked for open-cycle MHD. I urge the members of this subcommittee to appropriate this entire sum, which is designed to insure full funding for ongoing MHD efforts in Tennessee and eight other States.

I fully support the concept of the CDIF facility which is designed for low-sufur western coal. However, if the work in Tennessee is not funded, MHD technology will not progress as rapidly as the Nation has a right to expect. In addition, Tennessee is the only place where the technology is being developed to use high-sulfur coal in the MHD process. This sulfur-removal capability must be developed if we are to fully exploit the eastern reserves of coal in an efficient and environmentally acceptable way. This will translate into future billions of dollars saved in fuel shipping, powerplant, and reduction of coal requirements through high efficiency.

The University of Tennessee project can be carried out at very low cost ($5 million to $6 million per year). It will have the same or greater capability with eastern coal as the CDIF facility is expected to have with western coal.

We have the expertise. We have the present capability. We have the experience. Our future program is based on 15 years of success in the field, To show its

faith in this project, the Tennessee legislature has provided $5 million in matching funds to move ahead to the pilot plant stage.

We believe in Tennessee that MHD holds great promise as one of the prime solutions to our Nation's energy crisis. With minimum assistance from the Federal Government, we are confident that we can put this technology to work.

Mr. YATES. Do you want to tell us why you want this appropriation?

I know the University of Tennessee has for years been one of the leaders in producing MHD power and in the research, and we find that ERDA is much more enthusiatic about MHD this year than it was last year. So I think we are glad to see we are moving in that direction.

We will be glad to hear what you have to say.

Mr. GORE. Thank you very much. I appreciate your making the time available on relatively short notice. It means a lot to me and it means a lot to the people in my district who are involved with this project.

John Dicks is here with me, and I would like, with your permission, to put his statement in the record also.

Mr. YATES. His statement may be made a part of the record.

[Mr. Dick's statement follows:]

PREPARED STATEMENT ON MAGNETOHYDRODYNAMICS (MHD)
PRODUCTION OF ELECTRICAL ENERGY

to the

House of Representatives Subcommittee on Department of
Interior and Related Agencies Appropriations

by John B. Dicks, Director
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April 1977

Thank you for this opportunity to present my position concerning ERDA's magnetohydrodynamic (MHD) program requests for fiscal year 1978.

ERDA's massive study "Comparing New Technologies for the Electric Utilities" just issued, finds that four coal technologies show promise; fuel cell with gasifier, magnetohydrodynamics (MHD), atmospheric fluidized bed, and combined cycle turbine gasifier. ERDA's "Energy Conversion Alternatives Study (ECAS)" reports similar results and Business Week, December 6, 1976 quotes the General Electric Company section of ECAS showing MHD/coal plants as being the least expensive source of electrical power. Although such studies require much hardware testing for confirmation, they all project an important place for MHD in the Nation's future power system. This place is earned by its potential for inexpensive sulfur removal from high sulfur Eastern coal and by projected efficiencies of 55 percent even in early versions of the plant. Thus, as one of the vital energy programs in the country, MHD deserves sufficient funding to be carried in development. I thus ask that ERDA's request for $50 million in FY 1978 be increased by $15 million. I make this request because demand for funding by the CDIF in Montana ($28 million) and for the cooperative program with the Soviet Union so deplete the requested funding that the programs actually producing data on MHD coal power production will be severely curtailed.

Testimony before the Congress clearly shows that the only MHD power conversion from coal anywhere is at the University of Tennessee's Tullahoma existing installation. Here not only is power production accomplished from coal at flow rates of 2 tons per hour, but also a model of most of the critical hot gas portion of an MHD power plant is being demonstrated successfully. The aspects of high temperature coal combustion at 5000°F have been shown, power generation with coal combustion gas at 4300°F and with full slag content has been demonstrated, slag separation beginning at 3800°F proved and boiler tube construction beginning at 3900°F with very high gas velocities is being experimentally developed.

All of these particular technical areas must be developed in order to achieve success in MHD. Many of the parameters are greatly in excess of those that have been used anywhere before. In the case of MHD, vital components of what will constitute a half billion to billion dollar power plant, depending on size, must all be developed. If any of these components cannot be developed in economically competitive form then the MHD plant for practical application will not be built.

In addition to the work on components, various chemical processes must be developed in MHD. An example of this is the addition and removal of potassium from the flow in such a way as to allow the MHD generator to work and at the same time remove all the sulfur from the flow to control sulfur pollution. Chemical recovery and regeneration of the potassium affects the economic status of the MHD process to such an extent that failure to develop economical recovery would make the MHD process too expensive to use in practical power plants. The Tullahoma installation, at the University of Tennessee is the only place that this work is being accomplished and demonstrated on a sizable scale (2 tons of coal per hour). The results of these demonstrations to date are exceedingly satisfactory (large scale sulfur removal and 90% potassium recovery have been accomplished) and optimistic, but much work lies ahead before the plant can be a reality and here is the only place it is being performed or can be performed in the next several years.

In energy research and development the entire process must be carefully planned through all of its stages leading to application. If this process is delayed or breaks down in any stage, then the American people do not get the benefits of the development. Past experience has shown that the majority of inventions reaching large commercial application do not arise in either governmental or industrial laboratories and only reach such organizations after a considerable amount of work has been done elsewhere. These facts are documented in books such as "Sources of Invention", Jewkes et al. and in reports prepared by ERDA's public distribution during their public meeting on Patent Licensing. This may well occur because smaller organizations such as universities can move at great speed and are not hampered by any of the commercial and economic decisions that must be made by industry. Thus, such fast-moving organizations do the beginning work in a new technology and we usually have left-to-chance the transfer of the technology from the organization that begins the work to the industrial organization that later does large scale demonstration and manufacture.

ERDA handles the problem of technology transfer by issuing a series of RFQ's which often results in awards to organizations with little or no prior experience in a given field, or the technology might be taken up by a government laboratory with a similar lack of experience. An example of this procedure is the CDIF in Montana where responsibility is divided among some seven organizations, none of which has successfully operated MHD systems and particularly none have ever operated MHD systems involving coal. As a result, this standard procedure is expensive to the taxpayers and causes great delay in the energy program during the technology transfer period.

Recognizing the technology transfer problem, the University of Tennessee planned its program of MHD development so as to involve industry in the project while it is still under University management. Thus, in the beginning control rests with the people who have the greatest familiarity with the program and industry will not have to pursue a program in a technology that is initially unknown to it. By such a team composed of industrial and university personnel working side by side, the technology is optimally transferred from the University people directly into industry. We would envision that industry would take on a larger and larger role as familiarity increases during the MHD program's progress.

The University of Tennessee's program is exceedingly cost-effective in that the University has designed, largely procured or is procuring a facility designed to run on Eastern coal which has higher flow rate capability than the CDIF, represents a complete system rather than just a test facility for it which includes combustors, boilers, slag separators, seed recovery, pollution control, which models the eventual MHD plant. The cost of these in Montana is included in the test budget rather than in the facility budget. The capital cost of the plant that the University of Tennessee is constructing is $6 million in contrast to the incomplete plant in Montana at $37 million. For example, the MHD channel alone for the Montana facility has been contracted to AVCO, Incorporated, for $19 million. Other pieces of equipment are likely to be as costly.

The University of Tennessee has carefully chosen leaders in the commercial field of electrical power equipment. Its subcontractors are Babcock and Wilcox, one of the four largest suppliers of coal power equipment in the United States, and Burns and Roe, Incorporated, architect/engineers who have one of the largest involvements in the United States in energy development work as well as in the commercial construction of power plants.

Work at the University of Tennessee was not started on an RFQ, but by an unsolicited proposal which grew out of ten years of technical experience and the first successful demonstration of coal-fired MHD in the world. It was recommended by the Congress after several years of hearings on the subject was finally funded by the government. This unsolicited proposal was made with cost-saving in mind using creative imagination to reduce the cost of MHD development. For example, it pointed out to the government that for this facility size (three to ten tons of coal per hour) separately fired preheaters which would have cost on the order of $15 million could be eliminated, and a device called vitiation heater ($100 thousand) could be substituted. This creative idea has been adopted by ERDA and the cost savings passed on to the Montana facility. Also, the University of Tennessee, as shown in Figure 1, has located much of its equipment on the outside taking advantage of the mild climate to avoid expensive protective structures. Figure 2 shows ERDA's Eastern coal facility that is being built in Tennessee is designed with most of the equipment on the outside. This results in great reduction in cost for objects such as the 10-story high coal feed towers. The existing University of Tennessee facility was operated unhampered by recent severe weather conditions this past winter.

Such cost-savings in general would not be possible in ERDA's standard RFP approach where the government specifies the facility and does not have the internal experience to save cost through creative design.

The Congress thus has before it two programs, one being managed in the conventional way on Western coal, and the other one on Eastern coal being carried forward by two well-known industrial organizations with the University of Tennessee in the lead. It is worth following the progress of these two programs which are directed towards different; but technically comparable objectives. We already know from experimental

operation of simulated Western coal at the University of Tennessee facility that the ultimate design of the two power plants will be considerably different, with sulfur removal being emphasized in Tennessee and the problems of handling the spontaneously combustible Western coal with its corrosive slag being the primary objective in Montana.

We, therefore, ask that the Congress lend its support and protection to both programs; Montana in its need for adequate funding through ERDA's conventional development process and in Tennessee to protect its cost-effective program by supplying the relatively small funding to ERDA's budget required for its continuation.

For future years the State of Tennessee has shown its faith in MHD technology and in a continuation of cost-effective energy development by creating the Energy Institute and by providing $5 million in matching funds towards the beginning of organization for an MHD power plant effort on Eastern coal in Tennessee. If our cost-effective management efforts and technology development prove to be as we expect, we would like your approval to continue our efforts into an Eastern coal pilot plant in coming years.

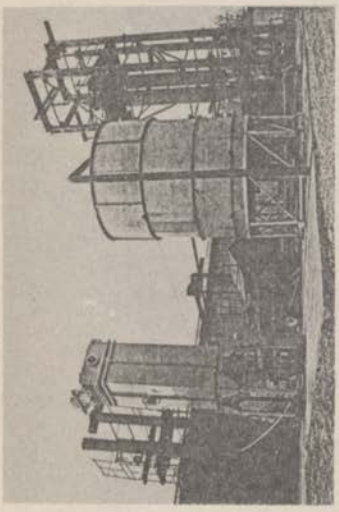


FIGURE 1. MHD UTSI FACILITY SHOWING COAL TANK, BAGHOUSE AND CYCLONE SEPARATORS FOR SULFUR REMOVAL

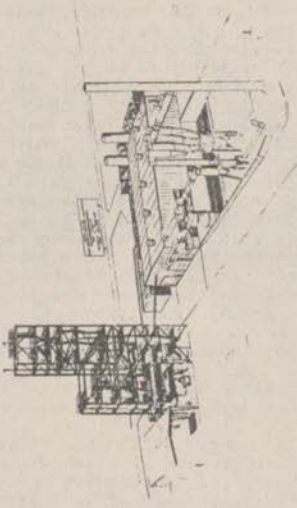


FIGURE 2. ERDA'S EASTERN COAL FACILITY BEING BUILT IN TENNESSEE

Mr. YATES. I remember talking with Mr. Dicks last year, and I was asking about Montana, not about Tennessee, last year.

Mr. GORE. Yes. The political history of this whole process is extremely significant, as your testimony earlier this year indicated that you are quite aware of the political history of this, and in spite of that history we support the CDIF facility and it's different technologies.

We think we ought to proceed with both technologies.

In general, I guess it ought to be said that the magnitude of the problem has grown so enormously that the magnitude of our efforts to solve the problem ought to grow in proportion, or so it seems to me.

We are excited about the developments in Tennessee. It holds the promise of increasing the efficiency of coal by 50 percent and at the same time cleaning up the environmental problems that are associated with the massive conversion to coal which the President has proposed.

We feel it would be penny wise and pound foolish to do less than a full exploration of this technology.

Mr. YATES. OK. Thank you.

Did you want to say something, Mr. Dicks?

Mr. DICKS. Yes; just one thing.

In your hearings on the 25th you asked ERDA could they have not gone ahead more cheaply in Tennessee.

Mr. YATES. Yes.

Mr. DICKS. We know there is an extensive background to this that causes them to do otherwise, but they said essentially no; they could not because it was a university in the lead position.

I think we objected to that on a philosophical ground, because there is a lot of evidence in the record that most innovative developments that reach commercilization do not arise either from the Government laboratories or the large industrial laboratories, and there are some references in my testimony supporting that fact.

We realize that the university is not going to manufacture anything, and so we have essentially followed the route of bringing industry in as major subcontractors, in order to bring them along and then transfer the technology to them.

We somewhat object to the idea that one can go out with an RFP give a technology to a group that completely is largely inexperienced in an area, and come up with as good an effort as one can arrive at by combining people with the experience who carried the inventions forward to a certain extent, and those who will take it on later.

We have an ERDA program too, and it's moving rather nicely now. Ours concentrates largely on eastern coal, almost totally on eastern coal. We think this economically to the country is somewhat perhaps more important than even the western coal is, as important as it is, because our centers of population are close to eastern coal.

By unit train, it costs something like $20 to ship a ton of coal from say the Wyoming area into the East. Now, there is a lot of good bituminous coal in the West, in Utah, and so forth that is like the eastern coal. But this will have a profound effect, because one of the great advantages of the MHD process is its capability of sulfur removal.

We have demonstrated and are demonstrating in the laboratory that you can burn it in a realistic system and take virtually all of the sulfur out, and that works rather well.

So it may make eastern coal usable, in a way that other processes do not, because the sulfur removal is rather cheap.

We are not asking for a lot of money, because we feel that our experience gives us an advantage, and we expect to get up a facility which is comparable to the one in Montana for roughly about one-fifth the cost. It's a rather neat effort with Babcock & Wilcox, our major subcontractor, Burnes & Roe, architect engineers, rather than the large number of people that ERDA is involving in Montana, so it will provide an interesting contrast as time goes on.

If we are successful we would hope to persuade the fossil fuel division of ERDA that universities have some capability in the fossil fuel area.

Mr. YATES. At least our committee believes so.

Mr. DICKS. We, of course, support the work in Montana. There are other good university efforts. There is a spectacular one at Mississippi State where they have put together vast amounts of surplus equipment from the space effort into a facility that is worth several millions of dollars roughly, at no cost to the Government.

There is work at MIT, and there is particularly good work at Stanford.

So we would like to convince the fossil fuel division by demonstration, and I guess the country in general, that universities should not really be put into a subordinate role too early in the fossil fuel energy programs.

Mr. YATES. Thank you very much.

Mr. Evans?

Mr. EVANS. Could I ask a question?

How far away do you think you are from commercialization?

Mr. DICKS. We perhaps are 10 years technically away from commercialization. However, there are management problems in organizing the various efforts and unless the country solves these management problems we may be 15 years or 20 years away.

Mr. EVANS. What are the management problems?

Mr. DICKS. Just simple delays in the Federal procurement system, in their reviews of designs.

Of course, we, as many workers in the field, feel that essentially you should get a good, competent group together and let them go with a minimum amount of supervision, and that they will move faster this way.

Historically, the Atomic Energy Commission, and now it's appropriated into the rest of ERDA, maintained a very rigid supervision, and it was much easier for them to do this because over a period of time they had tremendous numbers of trained people that could watch everything.

In the sudden expansion into brand new technologies, the Government is just strapped from the fact that they just don't have enough people, I feel, in these emerging areas to manage as tight a program as the Atomic Energy Commission did, and as a result we can document a factor of say two delays in our program, which is a rather simple one from an administrative standpoint.

Mr. EVANS. If you had the administrative problem licked, what timeframe would you then have?

Mr. DICKS. We would expect demonstration in 10 years if we could lick that problem, which is in the near time. But this essentially explains the difference between the current Government estimate of demonstration and our estimate. Theirs is realistically based on the system under which we are now laboring.

Mr. GORE. If I could make one point here. I think is an important one, the reason why OMB has recommended a cut in the budget for this is they viewed it as a long term option and they made a choice to fund short term energy options and cut back on long term options. With a 10-year horizon, this becomes a midterm option, and it's my feeling that if we can develop increasing confidence in new technologies to come on line at the 10-year period, then that gives us a great deal more latitude in the short term.

If we have confidence that we can use the MHD process in 10 years to convert to coal without the environmental impact, then we can talk about accelerating production of some of the other fossil resources to get us over the hump within the next 10 years.

In other words, I think the short, midterm and long term policies ought to be examined within the same context, because this is part of the same problem.

Mr. EVANS. Management is adding how many years to this delay?

Mr. DICKS. It's doubling our time, and we have this well documented because we have a very discreet start point. We were started essentially by the Congress in December of 1973. It took ERDA, rather their predecessors, the Office of Coal Research, a year to negotiate a contract with the university that was ready to buy all of the Federal regulations.

Thereupon, we went out to contract with our subcontractors. It took 9 months to negotiate those contracts, even, and most of that was after we had selected by the competitive process the contractors that we need.

Mr. EVANS. Because you had some administrative layers of review or what?

Mr. DICKS. We would write a certain type of contract that we believed was warranted and the Government negotiators would tell us to go back and write an entirely different kind of legal contract or else we would get in with the industrial people in very elaborate negotiations over various features of the contract.

That was 2 years ago. I hope that has been somewhat streamlined, but we have seen some recent RFQ's that are really quite elaborate.

If I were Administrator of ERDA, I would perhaps come to the Congress and ask them to streamline the Federal procurement regulations that have been built up in such elaboration that it slows everything down and I have testified against these regulations in a number of cases.

The legal staff in general will admit this clause that is causing you trouble has never been applied to any contractor in the entire history of the United States, and it maybe has been in there since 1945. From an operational standpoint, if those clauses give one trouble, they should be striken. Or if we go along with the President, that we are in

essentially a war with the universe, in order to maintain our standards, then we should use wartime procurement regulations, which are really spectacularly different.

Some of the people that like the process we now have say that people will steal money or do something or other. I think the amount of money we lose by that route is miniscule compared to the amount we lose by delay.

Our cost has gone up on this contract by say 30 percent just simply because of inflationary delays.

Mr. YATES. We have criticized ERDA before you for the terribly long period of time, and we talked about the complexity of the contracts and difficulties, and so forth.

Mr. DICKS. It takes fortitude to come up to the Congress and say we must do something about these, and it would mean grinding through Government operations, because that is where it is, through some service, and people are reluctant to begin that process.

Mr. YATES. We will admonish them about this in our consideration.

Mr. DICKS. The Administrator could, by fiat, make a new set of regulations, but that is requiring a great deal of courage, because he would immediately be accused of trying to give away the people's money, in some quarters, I think.

Mr. YATES. A few administrators do that.

Mr. DICKS. Yes; I think this is really the central problem that could be solved in the energy situation.

Mr. YATES. OK. Thank you very much.

Mr. GORE. Thank you.

Mr. YATES. Thank you.

We will come back at 1 pm.

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