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ERDA AUTHORIZATION
FISCAL YEAR 1977—PART V
ENVIRONMENT AND SAFETY

GOVERNMENT

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DOCUMENTS

JAN 29 1977

HEARING

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SUBCOMMITTEE ON ENERGY RESEARCH,
DEVELOPMENT AND DEMONSTRATION

OF THE

COMMITTEE ON

SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

SECOND SESSION

FEBRUARY 23, 1976

[No. 93]

Part V

Printed for the use of the
Committee on Science and Technology



U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1976

78-866 0

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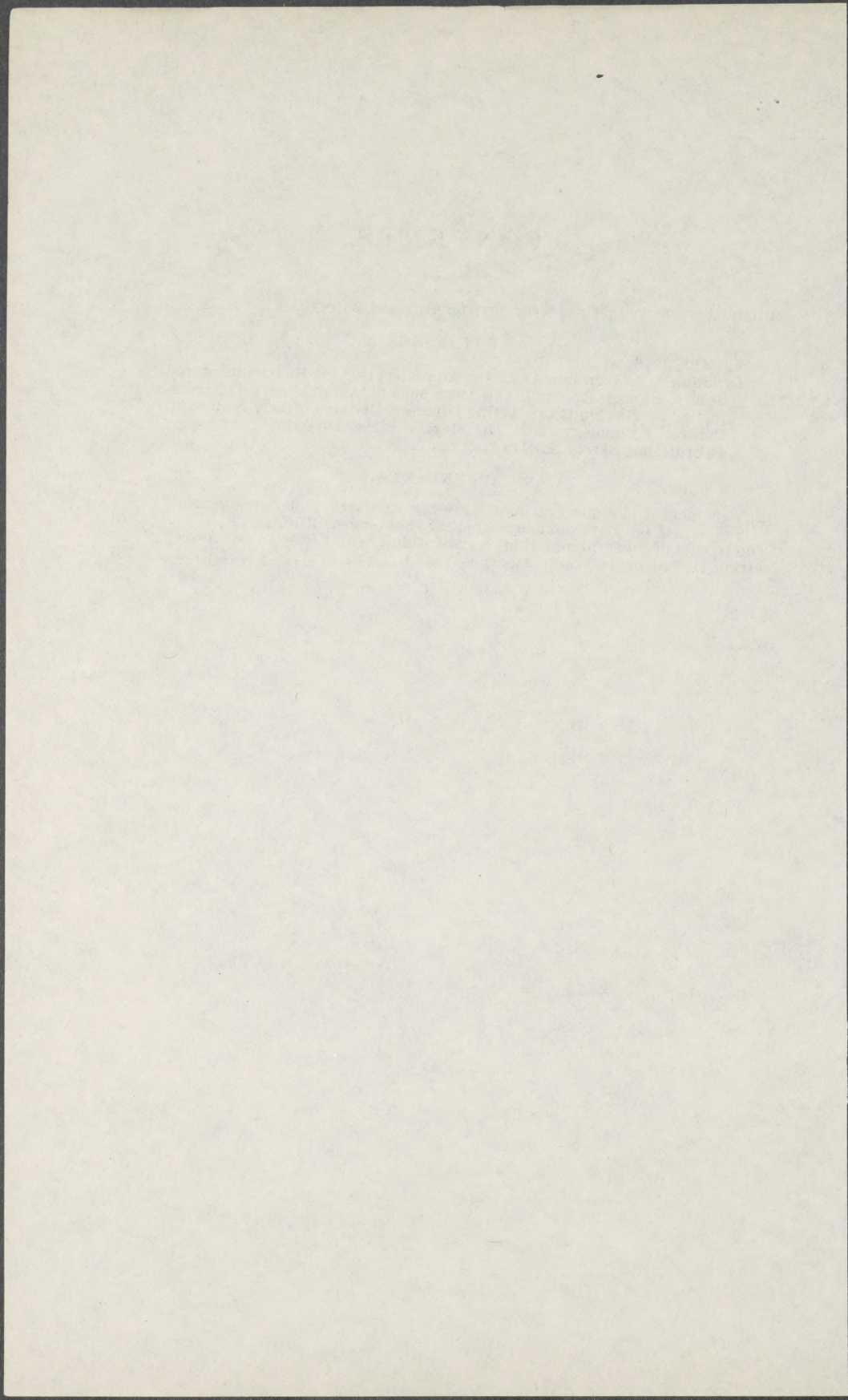
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ENVIRONMENTAL RESEARCH AND SAFETY

[In thousands of dollars]

Operating expenses	Actual fiscal year 1975		Estimated for fiscal year 1976		Requested for fiscal year 1977	
	Budget authority	Budget outlays	Budget authority	Budget outlays	Budget authority	Budget outlays
Biomedical research	\$142,472	\$134,618	\$174,547	\$164,365	\$182,916	\$174,734
Environmental control technology	8,203	7,143	12,567	11,455	15,577	14,155
Operational safety	3,328	3,027	6,886	6,310	7,707	5,058
Total operating	154,003	144,788	194,000	182,130	206,200	193,947
Total capital equipment	9,935	9,114	11,480	11,065	11,978	11,629
Total plant	13,650	2,606	3,200	5,329	4,200	8,325
Total environmental research and safety	177,588	156,508	208,680	198,524	222,378	213,901

(V)

TABLE I			
Summary of the results of the experiments			
Experiment	Time (min)	Temperature (°C)	Yield (%)
1	10	100	100
2	20	100	100
3	30	100	100
4	40	100	100
5	50	100	100
6	60	100	100
7	70	100	100
8	80	100	100
9	90	100	100
10	100	100	100
11	110	100	100
12	120	100	100
13	130	100	100
14	140	100	100
15	150	100	100
16	160	100	100
17	170	100	100
18	180	100	100
19	190	100	100
20	200	100	100
21	210	100	100
22	220	100	100
23	230	100	100
24	240	100	100
25	250	100	100
26	260	100	100
27	270	100	100
28	280	100	100
29	290	100	100
30	300	100	100
31	310	100	100
32	320	100	100
33	330	100	100
34	340	100	100
35	350	100	100
36	360	100	100
37	370	100	100
38	380	100	100
39	390	100	100
40	400	100	100
41	410	100	100
42	420	100	100
43	430	100	100
44	440	100	100
45	450	100	100
46	460	100	100
47	470	100	100
48	480	100	100
49	490	100	100
50	500	100	100
51	510	100	100
52	520	100	100
53	530	100	100
54	540	100	100
55	550	100	100
56	560	100	100
57	570	100	100
58	580	100	100
59	590	100	100
60	600	100	100
61	610	100	100
62	620	100	100
63	630	100	100
64	640	100	100
65	650	100	100
66	660	100	100
67	670	100	100
68	680	100	100
69	690	100	100
70	700	100	100
71	710	100	100
72	720	100	100
73	730	100	100
74	740	100	100
75	750	100	100
76	760	100	100
77	770	100	100
78	780	100	100
79	790	100	100
80	800	100	100
81	810	100	100
82	820	100	100
83	830	100	100
84	840	100	100
85	850	100	100
86	860	100	100
87	870	100	100
88	880	100	100
89	890	100	100
90	900	100	100
91	910	100	100
92	920	100	100
93	930	100	100
94	940	100	100
95	950	100	100
96	960	100	100
97	970	100	100
98	980	100	100
99	990	100	100
100	1000	100	100

**ERDA AUTHORIZATION
FISCAL YEAR 1977
PART V—ENVIRONMENT AND SAFETY**

MONDAY, FEBRUARY 23, 1976

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY RESEARCH,
DEVELOPMENT AND DEMONSTRATION,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2 p.m., in room 2318, Rayburn House Office Building, Hon. Mike McCormack, chairman of the subcommittee, presiding.

Mr. McCORMACK. The meeting will come to order. I apologize to all present for my tardiness today. I try to be prompt at these meetings. In this instance, I had a situation that made it impossible.

In this afternoon's hearing the Subcommittee on Energy Research, Development and Demonstration will receive testimony on the ERDA environment and safety programs in the context of the proposed budget for fiscal year 1977.

Both the Energy Reorganization Act and the Federal Nonnuclear Energy Research and Development Act set forth strong directives for ERDA to discover and solve or prevent environmental problems associated with the development and commercial demonstration of new energy technologies. Achieving solutions for environmental problems associated with energy research, development and demonstration is to be an integral part of the comprehensive energy plan.

I think this is important in bringing balance to our energy program in the nuclear and nonnuclear areas.

The Geothermal and the Solar Research, Development, and Demonstration Acts (P.L. 93-410 and P.L. 93-473 respectively) also specified that environment and safety should be primary factors in the development of these energy technologies.

The legislative mandate to address these problems is clear. In the proposed budget for environment and safety programs, less than 4 percent of the total is addressed specifically to solar, geothermal, and conservation programs. Another 22 percent is categorized as being multitechnology in scope. The subcommittee wants to analyze what will be accomplished in the coming year with the proposed budget and what information and instrumentation need to be developed in a more expeditious manner.

Another area of major responsibility assigned to the ERDA, in the organic acts, is the education and training of a cadre of scientists, engineers, and technicians to insure sufficient manpower for the orderly

development and commercialization of the new energy technologies. It takes up to 10 years to generate the necessary technical manpower to fulfill anticipated requirements in certain fields. In looking at the proposed budget, the subcommittee is concerned about the lack of appropriate attention to this major responsibility. We will want to know what studies are being conducted by the ERDA and the National Science Foundation to determine the magnitude of the manpower training problem over time.

Our witness today is Dr. James Liverman, Assistant Administrator for Environment and Safety. He is accompanied by Mr. Hal Hollister, the Acting Director of the Division of Environmental Control Technology, and Dr. Martin Biles, Director of the Division of Operational Safety.

It is again a pleasure to welcome you, Jim. Please introduce your associates.

You may insert your statement in the record and speak from it.

STATEMENT OF DR. JAMES L. LIVERMAN, ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY, ERDA

Dr. LIVERMAN. I would like to submit the statement for the record and, through the use of a few viewgraphs, try to point out to the committee some of the accomplishments of the past year since we became ERDA and then discuss some more details of the budget.

[The prepared statement of Dr. Liverman follows:]

STATEMENT OF DR. JAMES L. LIVERMAN, ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY, U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Mr. Chairman and Members of the Committee: I am pleased to have this opportunity to appear before the Subcommittee on Energy Research, Development and Demonstration to discuss the Environmental Research and Safety FY 1977 request, especially for the nonnuclear energy activities.

I would like to discuss the FY 1977 budget request and highlight the activities which have taken place over the past year in the nonnuclear portion of three of the Environment and Safety programs—Biomedical and Environmental Research, Environmental Control Technology, and Operational Safety.

With the transition from AEC to ERDA, the Biomedical and Environmental Research (BER) program has been deeply involved in a number of activities to ensure that its research efforts are responsive to the health and environmental problems confronting all energy technology developments—not just nuclear—in order to minimize their impact on man and his environment.

In the past year, a significant fraction of our research effort has been redirected into the nonnuclear (primarily fossil) area. A balanced program plan (BPP) of biomedical and environmental research needs has been developed and implemented within the limits of our resources, and the first inventory of energy-related biomedical and environmental research supported by agencies of the Federal Government has been completed. Thus, Mr. Chairman, we are involved in a significant way in being responsive to our new and broadened mission to ensure that this nation's energy needs will be met in an environmentally safe and timely manner.

Wherever it is possible, we have attempted through redirection of research and through new initiatives to develop integrated, interdisciplinary efforts which cut across the BER program and address the total research needs related to a specific technology. For example, in FY 1976, a coordinated, integrated research program in support of coal conversion is being planned for Oak Ridge National Laboratory to characterize chemical pollutants in process and/or effluent streams, identify biologically hazardous agents through rapid screening tests using *in vivo* and *in vitro* biological systems, determine biological and environmental effects, and assess the health, environmental and socioeconomic impacts. In this work, samples from the synthoil process and synthane pilot plant at the Pittsburgh Energy Research Center (PERC) are being used. As another example of an

integrated research effort, the Lawrence Livermore Laboratory is now coordinating an integrated research program, including the use of university capabilities, to develop baseline data in the Imperial Valley in parallel with development of geothermal energy sources there. A similar effort is in the planning stage for oil shale.

The reason for mentioning these integrated efforts (especially the geothermal studies) is to illustrate an important point—a need for flexible funding. In fiscal year 1976, it was possible to mobilize operating and equipment funds and laboratory and university manpower to initiate baseline environmental studies along with the start-up of geothermal technology activities in the Imperial Valley. Reasonable flexibility in moving funds around insures that important problems can be addressed as opportunities for doing so arise. This is not possible when funds are rigidly constrained to specific problem areas.

I would also like to emphasize that a significant fraction (31.2 percent) of our research effort is devoted to work that is in support of more than one technology. These activities are categorized as multitechnology and general science. The former pertains to more applied supportive work (studies of thermal effects, offshore oceanographic research, etc.) and the latter relates to more fundamental supportive work. It is imperative that such work be recognized for its importance in resolution of technology-related health and environmental problems.

For fiscal year 1977, \$174.7 million is requested for support of biomedical and environmental research. This budget request represents an increase of \$10.3 million over the fiscal year 1976 congressionally approved level of \$164.4 million. With this funding, research in the nonnuclear area will increase to a level of \$44.1 million from \$33.3 million. The largest portion (\$37.4 million) will be used in support of fossil energy technologies. To attain this proposed level of support for nonnuclear energy-related research, it was necessary to redirect funds from other research activities. In doing so, however, all attempts are being made to insure that high priority nuclear and multitechnology research is maintained at a viable level.

Now, Mr. Chairman, I will go into a little more detail concerning BER activities and accomplishments in fiscal year 1976 and our plans for fiscal year 1977. In doing so, I will be focusing on the technologies rather than budget reporting categories.

In summary, let me point out that our nonnuclear research efforts are focused on near- and mid-term technologies; however, at the same time, work in support of mid- to long-term technologies is also in progress.

FOSSIL ENERGY

Because of the importance of fossil energy as a near- and mid-term energy source, 84.8 percent of our proposed nonnuclear program addresses problems related to fossil energy, and 86.6 percent of this fraction is in support of coal, 8.8 percent in support of oil and gas, and 4.6 percent in support of oil shale. In addition, as I mentioned earlier, much of the multi-technology activities are equally related to fossil energy technology operations as well as nuclear technology developments.

The health effects of fossil fuel technology development are addressed in a variety of research activities intended to evaluate the early and latent effects of recognized and potentially hazardous agents produced in the various processes of extraction, conversion, and utilization. These include studies of the metabolic transformation of agents, the identification of the carcinogenic and mutagenic potential of various organic compounds, pathophysiological effects, respiratory toxicology, and reproductive and embryotoxic effects. I would like to point out specifically that with continued redirection of work, a new pulmonary toxicology program will be initiated at Brookhaven National Laboratory. It is also anticipated that research in hyperbaric medicine (deep-sea diving for offshore oil and gas) will be expanded in fiscal year 1977 in cooperation with the National Oceanographic and Atmospheric Administration, the National Heart and Lung Institute, and the National Institute of Occupational Safety and Health in high priority areas identified in a plan being developed for the health and safety of deep-sea divers.

The biological studies program has initiated a cellular screening program for the rapid systematic bioidentification of mutagenic and carcinogenic agents in fossil products, effluents, and wastes. These tests will be validated by animal tests to produce dose effect measurements to guide control measures. Cellular toxicology studies are in process to quantitatively determine the health risk from toxic agents. To overcome time limits of human epidemiological and whole

animal studies, studies of key cellular macromolecules and structures are in process. These will provide the basis for understanding and predicting the occurrence of pathological processes.

Several environmental studies were initiated to investigate the environmental problems caused by resource extraction and to develop and evaluate methods of reclamation and damage prevention. Specific projects dealing with revegetation, biochemistry, wildlife habitat, mobilization of toxic elements, water contamination to aquifers, streams, and offshore zones were begun. Also initiated was a full range of studies on the chemistry, transport, plant and animal effects, and transfer of pollutants in the atmosphere.

The physical and technology program initiated studies of heterogeneous chemistry and gas-to-particle conversion mechanisms that govern atmospheric chemistry conversions. Studies were started to develop baseline and operational data on trace elements, organics and organometallics, and other low concentration agents for which information is meager.

SOLAR ENERGY

In the fiscal year 1977 budget submission, we have requested \$2.1 million for research in this activity.

To date, BER activities in the area of solar-technology research have concentrated on basic photosynthetic processes to support the development of bioconversion processes for the production of biomass and certain chemical feedstocks. Studies are also being performed to determine the detailed mechanisms of photosynthesis for use as detailed models for photovoltaic cells and for the generation of hydrogen.

Another research program deals with management of tree farms as a source of fuel and with methods to increase resin production through application of biologically active chemicals.

CONSERVATION

Our research effort (\$2.9 million) in this area is attuned to a number of problems, most of which are aimed at the increased production of food resources. In addition, however, characterization of effluents from a solid waste combustion power plant at Ames, Iowa, are being supported, and investigation to determine the potential genetic effects of strong magnetic fields are in progress. Research on the somatic effects of magnetic fields will also be initiated. It should be noted that these efforts will also have application to nuclear (fusion) technology as well as to ultra-high voltage electrical transmission.

GEOTHERMAL

In order to initiate studies in parallel with geothermal technology operations in the Imperial Valley, we have initiated through redirection and new funds, a fiscal year 1976 baseline study program (\$1.4 million), which is being coordinated through the Lawrence Livermore Laboratory. It is anticipated that this investigation will increase to a level of more than \$2.0 million in fiscal year 1977.

A valley-wide baseline and effect study is in progress to address the problems of air and water quality; ecological, health and socioeconomic effects; and to provide an integrated assessment of near-term and longer-term effects. The Imperial Valley Environmental Project (IVP) which has been organized to undertake this study, has been functioning for several months with the active participation of numerous public and private groups. In addition to the main IVP effort, a part is devoted at this time to site-specific measurements that are essential to the March 1976 startup and test of the ERDA/San Diego Gas and Electric Company Geothermal Development near Niland, California.

MULTITECHNOLOGY RELATED RESEARCH

Because of its importance, I would like to take a few minutes to discuss the work which is difficult to assign to any specific technology. Many problems are equally applicable to more than one technology and were, in fact, initiated because they were important to our earlier needs in the nuclear energy field. Yet, today, they are just as important in providing data which relates to fossil-energy technology development or nonnuclear energy technologies in general. Some of this work is supportive of several technologies and yet is applied in nature (for example, the biological and climatic effects of thermal effluents).

In addition, work that is also supportive of technology needs, yet is basic in nature, must be supported also. This category of research we define as general science. Work in this area is essential because it provides information on the fundamental structure and function of critical biological systems (molecules, cells, organs, organisms and ecosystems) which may be affected by energy-related pollutants. To understand the pollutant-induced effects, it is most important to know the mechanisms of normal biological processes in order to interpret the biological changes produced and learn how these are translated into deleterious effects such as cell death, mutations, cancer or other pathophysiological conditions. It is imperative that such work be recognized for its importance in resolution of technology-related health and environmental problems and, especially, with respect to the analysis and assessment of the health, environmental and national scales. As you are aware, the comparison of the impacts of the various technologies is important in cost/risk/benefit and tradeoff analyses.

Mr. Chairman, I would like now to discuss the environmental control technology program. The paramount objective of this program is to insure, through independent assessment and overview, that adequate environmental control technology capability is developed in concert with developing energy technologies so that the nation's energy demands can be met in an environmentally acceptable manner. These technologies themselves will be developed primarily under the energy technology development programs of ERDA, and not under environmental research and safety programs.

The overall fiscal year 1977 budget request of \$14.2 million for this program provides for an increase of \$2.7 million over fiscal year 1976. The major portion of the increase (\$2.3 million) will be applied to nonnuclear activities.

Among the highest priority tasks identified for support in fiscal year 1977, is that of assessing control capability and control requirements for use of fossil fuels for electric power generation. Specifically, we are analyzing the efficacy and practicability of options for: (1) the control of airborne pollutants such as sulfur oxides and their derivatives, nitrogen oxides, particulates, hydrocarbons and trace metals; (2) the control of polyaromatic hydrocarbons and trace metals in process wastewater; (3) the contamination of groundwater by infiltration of pollutants from disposal of waste ash, coal fines, and scrubber sludge; (4) adverse impacts due to the discharge of waste heat; and (5) the shipment of coal in slurry pipelines vs. trains. In addition, the assessments will consider, to the extent appropriate, other factors such as system cost and operability, which will have an impact on the potential utilization of control systems. Initial emphasis will be focused on available near-term alternative control technologies for coal combustion, specifically stack-gas cleaning following conventional combustion, fluidized-bed combustion, and pre-combustion coal cleaning. Later, the program will be extended to include other coal technologies such as low-BTU gasification and conversion of coal to synthetic solid and liquid fuels. We are also requesting funds for projects for assessments of control technology for first-generation coal conversion facilities; options for solid and effluent waste management for anticipated expanded coal extraction and preparation activities; and requirements for selected petroleum and gas energy sources including oil shale.

Although most of the fiscal year 1977 funds aimed at nonnuclear environmental control technology concerns will be directed at fossil energy systems, assessment activities dealing with geothermal energy, solar energy, and conservation will also be supported. More specifically, gaseous cleanup systems for geothermal systems will be evaluated, environmental implications of solar home heating and cooling systems will be identified, and environmental effects of high-voltage transmission lines and energy storage systems will be delineated.

The fiscal year 1977 budget also includes funds to start surveys and assessments and identification of gaps in ongoing Federal and industrial programs for transportation of nonnuclear fuels and wastes from energy programs. The initial assessment is aimed at establishing needs and objectives for further research and development and the identification of potential transportation problems early in the technology development. The emphasis will be on transportation safety of fossil fuels and materials.

In mid 1975, we initiated a marine oil-spill-prevention and cleanup study in conjunction with the U.S. Coast Guard and the Environmental Protection Agency (EPA). An early conclusion was that training was most important, not only in preventing, but also for expediting cleanup operations. Subsequently, an oil spill training program at Texas A & I University has been established, and the first

class is targeted for late this summer. The budget request provides for funding to expand our initial efforts to include the definition of a more comprehensive program for prevention and cleanup of oil spills.

I would like to conclude with a brief discussion of the Operational Safety program. The major portion of the funding for this program is in support of nuclear activities such as uranium mill tailings remedial action and aerial radiological monitoring system. The need for the first of these activities is based on providing corrective measures for those facilities in the Grand Junction, Colorado, area where unrestricted use of uranium mill tailings has created radiological hazards for occupants. The second, the aerial radiological monitoring system, is our primary accident response capability and provides an airborne monitoring system that has the capability to measure pollution discharges and dispersion patterns over a large area, which would be most important in determining the consequences of any major accident involving environmental releases of hazardous materials. In addition, studies are under way to extend the arms program into areas of nonnuclear environmental monitoring. The multi-spectral photographic and thermal scanning capability are being used in the geothermal studies I mentioned earlier.

The studies involving safety in nuclear-related facility design include, among others, research in more effective ventilation systems, effluent monitoring, respirator design recycle of contaminated valuable materials. Other studies which are specifically oriented towards the improvement of safety in all ERDA facilities and operations include evaluation of structure loading from tornado and seismic forces, as well as several individual studies on accident prevention and investigation. In addition, "seed" funds are included to initiate safety studies in nonnuclear facilities and operations where major problems have not been fully identified as of the present date. Investigative/corrective studies will be initiated on the more significant problems so identified in fossil, solar, and geothermal energy systems with additional funds provided in future budgets to complete these nonnuclear studies. Completion of these safety studies will provide the necessary knowledge, methodology, criteria and standards for ensuring that ERDA operations are conducted in a safe and healthy manner. It is the intent of the ERDA staff to continue its recognized leadership in accident-free operations in its nuclear facilities and to extend this practice to the nonnuclear area.

Mr. Chairman, this ends my statement and I wish to express my appreciation for the opportunity to present this summary of the Environmental Research and Safety nonnuclear programs.

Thank you.

Dr. LIVERMAN. I think you are aware of the budgetary history. I would like to outline some of the things we have done within the resource base that we have. It was originally a heavy nuclear oriented program. This year we shifted in a major way to cover nonnuclear areas on a priority basis. We developed a balanced program plan with the aid of our national laboratories since they would also be involved in implementation of the program. The plan covers all technologies with particular emphasis on the nonnuclear technologies.

We are in the process of updating the programs for fiscal years 1976 and 1977 so we will have a better overall appreciation of what is going on. We have initiated a new program in coal conversion and environmental effects at the Oak Ridge laboratories. We have also initiated, jointly with the Geothermal Division, a completely new program in the Imperial Valley which I will discuss in more detail later.

We set up a school to train people in how to clean up oil spills. Jointly with NIOSH and NOAA, we have supported the Underseas Medical Society in developing a plan to better address the hazards relating to offshore diving in conjunction with fossil fuel, and solar programs.

The administration has approved our plan for reorganization of the environment and safety structure to more effectively identify and address the energy technology problems.

Our restructured organization should enable us to work more effectively with the technologies, not only to review what they are doing,

but to help them in the formulation of a total program that would incorporate all of the environmental and related concerns.

We funded the CEQ to carry out its review of ERDA's environmental and conservation programs as required by the Non-nuclear Act. We meet in the morning at 8:30 with CEQ to go over their first reviews which were carried out last fall.

Congressman Wirth had asked about water resources in the mountain area. We have gone into joint programs with the Water Resources Council.

These are some of the more significant activities that have evolved over the past year.

I will now go to the slides, Mr. Chairman. We believe that there are four issues (slide 1) that must be taken into account at every stage of technology development. There is the technology research and development, the economics of the technology, the environment, health, safety, and societal issues, and also the institutional concerns.

Now, how do we incorporate those things into the ERDA programs. We feel that the most effective way to do this is to pull people out of the technology programs and people out of the environmental programs and provide for an interface so that together they will come up with an environmental development plan.

For each technology, regardless of what it may be, you must put together these four components in a focused program. This plan lays out as clearly as can be done, all the requirements which must be met for the energy technology to turn out safe and clean.

TECHNOLOGY DEVELOPMENT AND IMPLEMENTATION

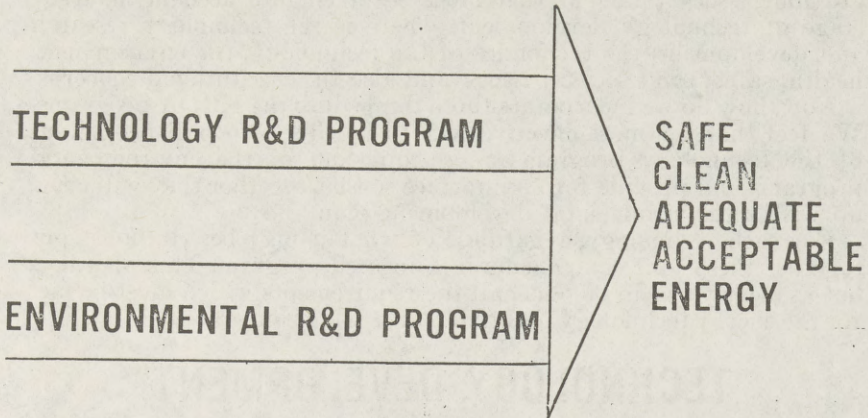
- TECHNOLOGY RESEARCH AND DEVELOPMENT
- ECONOMICS OF TECHNOLOGY
- ENVIRONMENT, HEALTH, SAFETY, SOCIETAL ISSUES
- INSTITUTIONAL ISSUES

SLIDE 1

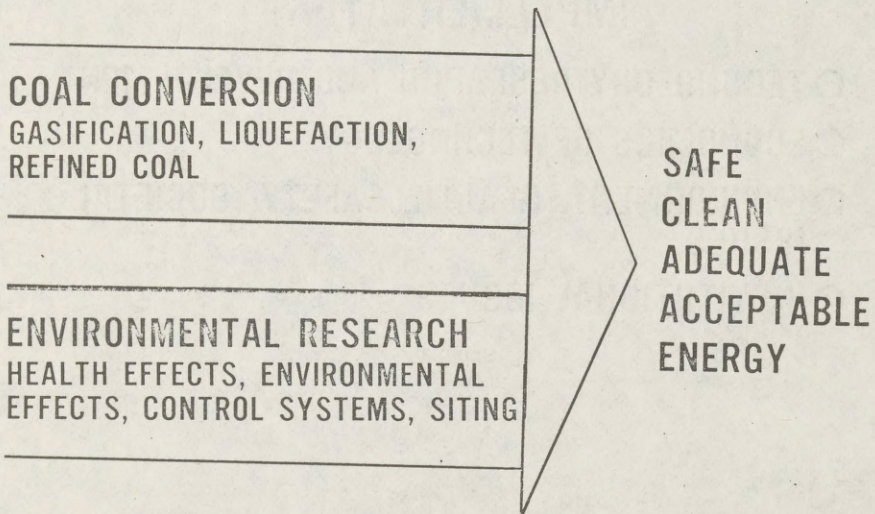
As an example take coal conversion and gasification (slide 3). You put a total package together so that the technology people and the environmental research people can be sure that we are taking into account all of the important issues that need to be addressed for each aspect of the problems in a timely manner.

Now in order to achieve this, it was necessary to reorganize. The reorganization has been approved as of today. As a result, we have brought into being teams of people in a new division represented across the top of the chart (slide 4). We will have people whose total

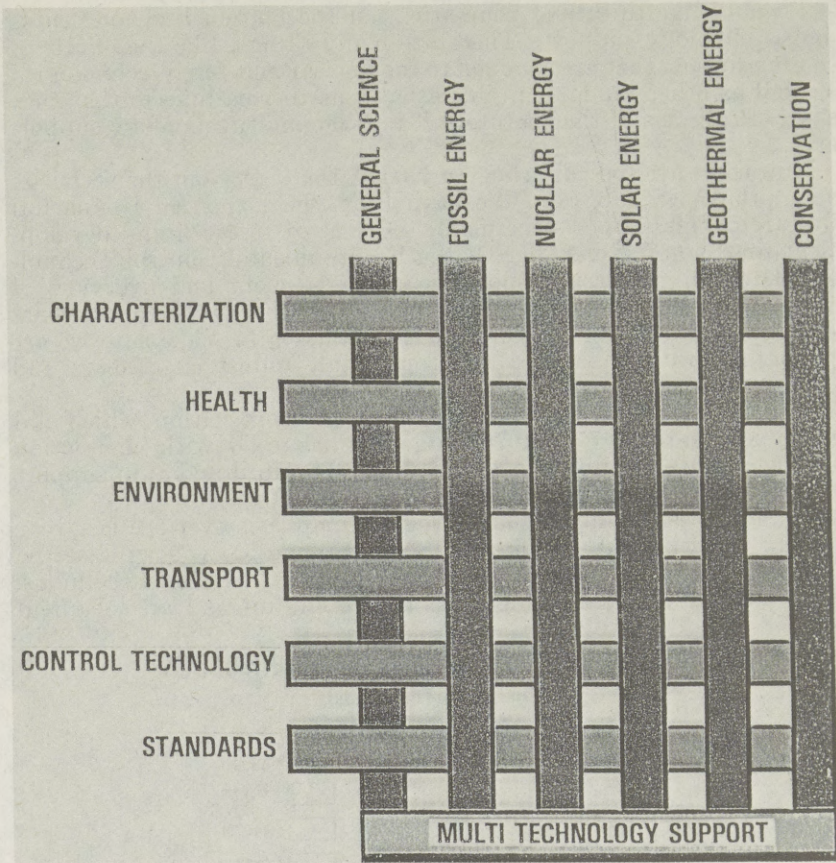
PLAN FOR SINGLE ENERGY TECHNOLOGY



SLIDE 2



SLIDE 3



SLIDE 4

concern is to work on the environmental plan and interface with the technologies to come up with programs which must be carried out to characterize the chemistry, physical behavior, and the health and environmental related issues for each technology.

By this interface, we can be sure that the necessary environmental, health, and safety concerns are taken into account by the technology. These people become advocates of getting work for their particular technology done in the total AES system. Therefore, along with the fossil energy people, the nuclear people, and the others, we hope priority programs and needs are addressed.

I would like to call to your attention the bottom line concerning multitechnology support. There are many things, like the effects of cooling towers, that are common to the nuclear and fossil technologies, as well as other kinds of problems such as thermal effects that they share. Programs of that nature fall into the multitechnology support area.

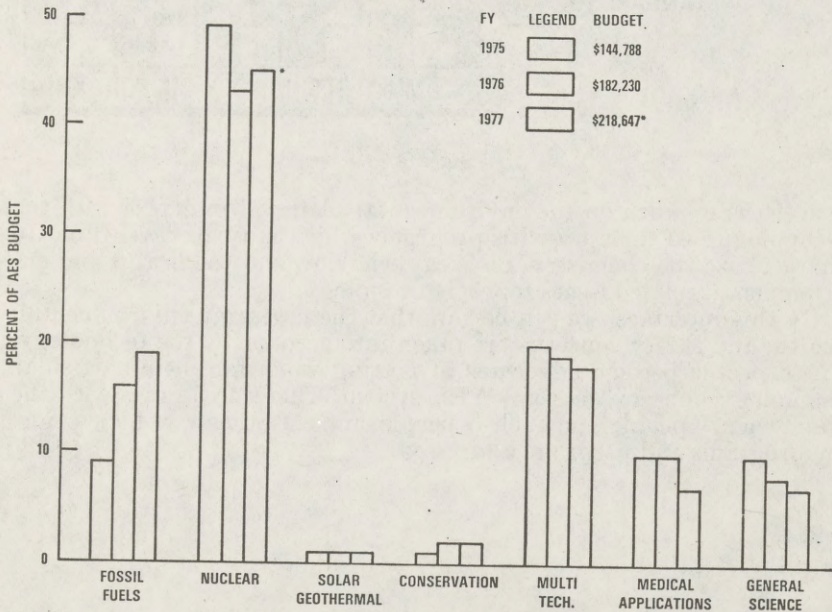
Now there are four divisions in ERDA that carry out the activities under the AES program. We have Biomedical and Environmental Research. This supports the major segment of research and development that is going on. There is the Environmental Control Technology Division which is responsible for assessment and overview of means to reduce pollution by the technology. There is the operational safety program which is the in-house watchdog to make sure we are complying with mandated environmental, industrial safety, and OSHA regulations.

Finally, there is reactor safety research coordination which did not appear in the 1975 or 1976 budget. It has to do with completion of experimental facilities in Idaho and at Hanford and is in support of Nuclear Regulatory Commission.

We have been trying to shift program emphasis over the last year and, if you will take a look at this slide (slide 5), you will see the 1975, 1976 and the 1977 budgets represented in the different columns. They indicate the fossil budget has been going up, as have solar and

AES BUDGET ALLOCATION BY TECHNOLOGY

(Dollars in Thousands)



*INCLUDES \$24.7M FOR REACTOR SAFETY NOT INCLUDED IN PRIOR YEARS.

geothermal on a much smaller scale. The point I want to make is that the shift has been out of the nuclear area to the nonnuclear areas.

The nuclear budget is somewhat misleading in the sense that if you subtract the reactor safety research program from the nuclear line, you would find that research and development in the nuclear area has gone down. The thing we have to keep rigorously in mind is that nuclear energy will become one of the major energy producers in the short term as will fossil energy. There has been considerable effort to shift programs into fossil with relatively less emphasis on other technologies that are likely to be a little longer in payoff but about which we have somewhat fewer concerns than with fossil energy.

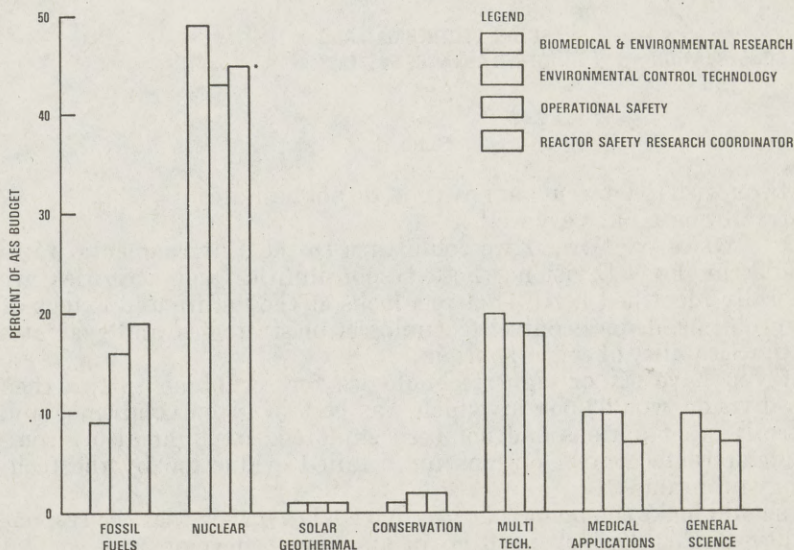
The next slide (slide 6) shows, on a percentage basis, the spread among various technologies in the fiscal year 1977 budget, with nuclear being 45 percent, including the \$24 million for RSRC. If you remove the \$24 million, it drops to about 40 percent and the others would increase accordingly.

If I could, Mr. Chairman, I would like briefly to discuss the programs of each division. The first is the Division of Operational Safety. It is very obvious, except for the next to the last line on the bottom, that all activities are nuclear related (slide 7). We are requesting \$200,000 for operational safety activities the details of which are shown on the next slide.

In the nonnuclear facilities, we are looking at questions of fire protection, personal safety and health, occupational medicine, and safe operating conditions.

AES BUDGET ALLOCATION BY DIVISION

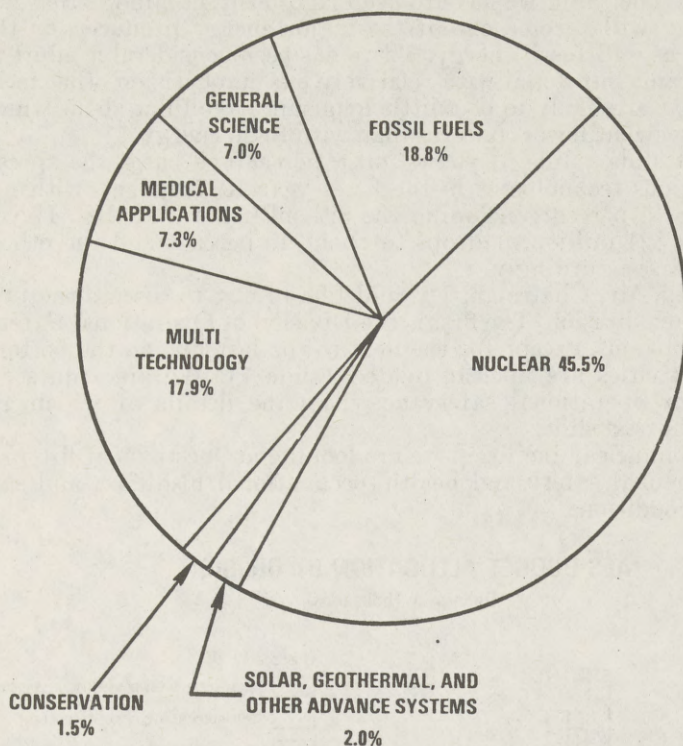
(Dollars in Thousands)



*INCLUDES \$24.7M FOR REACTOR SAFETY NOT INCLUDED IN PRIOR YEARS.

SLIDE 6

AES FY 1977 BUDGET REQUEST BY PERCENTAGE



SLIDE 7

If you wish to interrupt at any time, do not hesitate.

Mr. McCORMACK. Very well.

Dr. LIVERMAN. Now, if we could turn to the Environmental Control Technology Division whose responsibilities and activities are generally identified here. Thus one looks at the nature and extent of the problems, defines control technologies or strategies, and evaluates the practicability of control options.

If you have six or eight technologies for scrubbing sulfur, then this division would look at which was best in given conditions and to see if other options had not been explored. It might also recommend alternate control options for detailed evaluation by the technology programs.

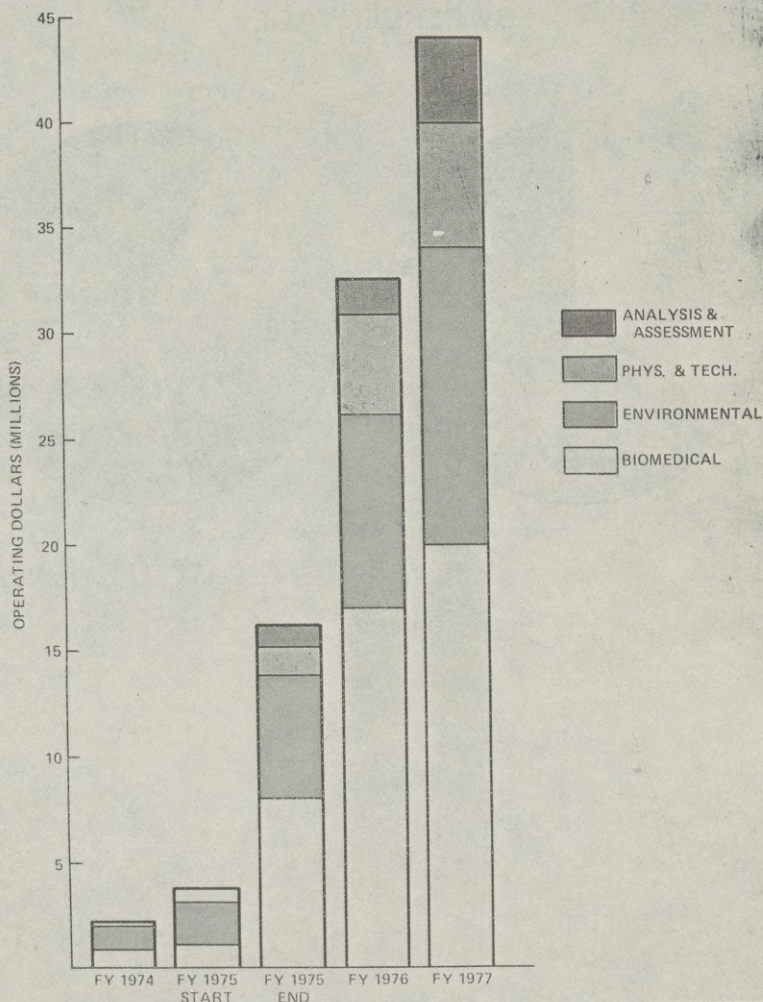
I should make the point that it is not ERDA's view that the responsibility of this division is to go in and try to develop new control technologies, except as a last resort. Rather, ECT would run a con-

tinual assessment and call any problems to the attention of the technology program when necessary.

As you can see in the next slide (slide 8), of the \$14 million being requested in the environmental control technology program, about \$10 million is for nuclear; \$3.5 million is for fossil; \$300,000 for solar; \$250,000 in geothermal; and \$300,000 in energy conservation.

Early last summer we had a program with Texas A & I University at Corpus Christi. It jointly involved the Coast Guard, the Navy, the Environmental Protection Agency, and certain State organizations. A training program for cleaning up oil spills was developed and the first class is scheduled to begin this fall.

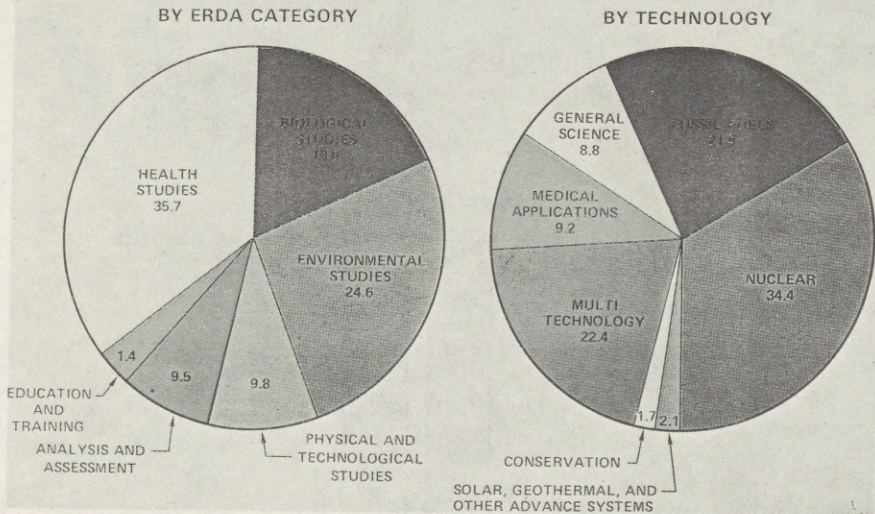
BER NON-NUCLEAR RESEARCH BY PROGRAM



SLIDE 8

I would like now to turn to the biomedical and environmental research program. In contrast to the total environment and safety program, this budget reflects pretty much what we believe the picture is; namely, a sizable increase in fossil and decreases in some nuclear areas. There is an increase in solar and geothermal as well as a fairly stable program in conservation, medical applications and general science. This next slide (slide 9) shows the health studies, the biological studies, the environmental studies and the physical and technological studies. On the right is another view by percentage showing about 35 percent in nuclear, 25 percent in fossil, and 22 percent in multitechnology.

BER FY 1977 BUDGET REQUEST ALLOCATION BY PERCENTAGE



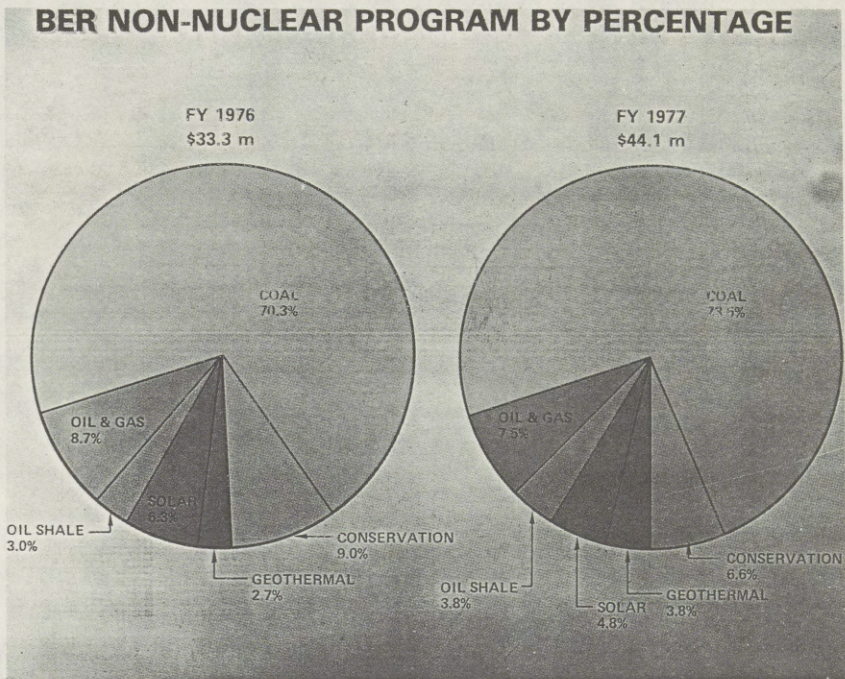
SLIDE 9

Of the nonnuclear programs in this particular division, this slide (slide 10) shows, by percentage, the major commitment to coal and fossil energies in general because of their pervading effect on the environment and our need to know as much as we can. At the same time we are trying to carry on programs in geothermal and conservation which is shown by the next slide (slide 11).

If you go back to fiscal year 1974, you can see that there is a very small commitment to the nonnuclear areas, \$2.5 or \$3 million. Over the past year and a half, we have made a major shift in terms of programs.

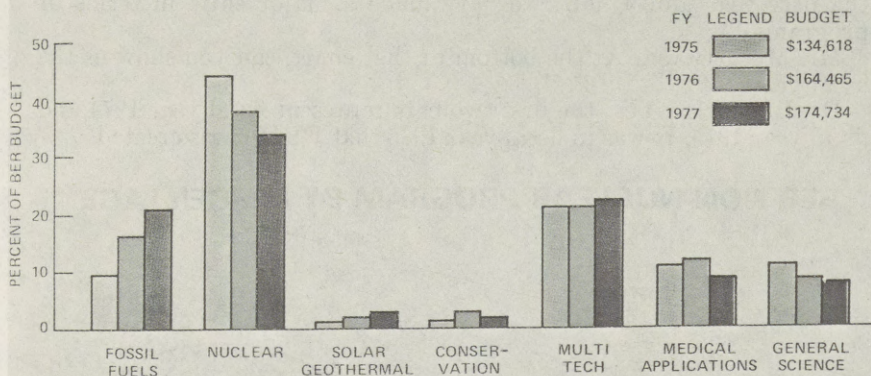
Mr. McCORMACK. At the bottom of that chart, can you show us the fiscal years?

Dr. LIVERMAN. Yes; the first two bars represent fiscal year 1974 and fiscal year 1975. It was in fiscal year 1975 that ERDA was created.



SLIDE 10

BER BUDGET ALLOCATION BY TECHNOLOGY



SLIDE 11

Mr. McCORMACK. Thank you.

Dr. LIVERMAN. Most of what has been done has been done with a relatively small increase in total budget. There has been a shifting of emphasis within the total program over that period of time.

Mr. McCORMACK. You may continue, please.

Dr. LIVERMAN. This shows in actual numbers as opposed to percentages, those same nonnuclear program shifts from 1975, 1976, and 1977, going from about \$16 million to \$44 million in fiscal year 1977 budget (slide 12).

In addition to the multitechnology area, which, as I mentioned earlier, is research and development focused on the technologies, we have the general science category, which pertains to basic supporting re-

**DIVISION OF BIOMEDICAL AND
ENVIRONMENTAL RESEARCH**
DETAILS OF PROGRAM BY TECHNOLOGY
(In Millions)

<u>NONNUCLEAR</u>	<u>75</u>	<u>76</u>	<u>77</u>
COAL	9.9	23.4	32.4
CONSERVATION	2.1	3.0	2.9
GEOHERMAL	0.3	0.9	1.7
OIL AND GAS	2.2	2.9	3.3
SHALE	0.2	1.0	1.7
SOLAR	1.6	2.1	2.1
<u>TOTAL NONNUCLEAR</u>	<u>16.3</u>	<u>33.3</u>	<u>44.1</u>
<u>MULTI-TECHNOLOGY</u>	29.3	35.5	39.2
<u>GENERAL SCIENCE</u>	14.5	15.2	15.3

SLIDE 12

search. This illustrates for you some of the kinds of things that are going on within that program (slide 13).

Mr. GOLDWATER. What are you looking for in the bottom category?

Dr. LIVERMAN. That is the analysis and assessment area which is aimed at trying to put together various kinds of existing information, such as health and environmental effects and business, economic, census, topographic and other data so that you are looking at all of the factors that might dictate the use of a given technology in a given region. If you have this kind of information together, it allows you to make choices, and people in the community and State, to make choices regarding the technologies they would like to see pushed in their areas.

The whole thrust is to provide the opportunity to analyze the socio-economic impact and institutional factors that impact on where people live and the environment that is there. You might be able to establish one shale plant, but not three.

MULTI-TECHNOLOGY/GENERAL SCIENCE RESEARCH

CMM

INSTRUMENTATION DEVELOPMENT FOR BIOMEDICAL RESEARCH
INSTRUMENTATION DEVELOPMENT FOR PARTICULATE AND CHEMICAL ANALYSIS

BIOMEDICAL

MECHANISMS OF DAMAGE TO CRITICAL ORGANS AND TISSUES
UNDERSTANDING HEALTH COST OF MUTATION LOAD IN MAN
MOLECULAR AND CELLULAR MECHANISMS OF POLLUTANT INTERACTION AND DAMAGE

ENVIRONMENTAL

THERMAL, CHEMICAL AND PHYSICAL EFFECTS OF COOLING SYSTEMS ON MARINE AND
AQUATIC BIOTA
BIOLOGICAL AND PHYSICAL OCEANOGRAPHY BASE LINE STUDIES IN COASTAL ZONES
RESEARCH ON THE STRUCTURE AND FUNCTION AND INTERACTIONS OF NATURAL
ECOSYSTEMS

ANALYSIS AND ASSESSMENT

ASSESSMENT OF ENERGY CONSERVATION IMPACTS AND ALTERNATIVES IN THE
NORTHEAST
DEVELOPMENT OF SOCIOECONOMIC MODELS FOR EVALUATION OF IMPACTS OF
ALTERNATE ENERGY TECHNOLOGIES

SLIDE 13

Mr. McCORMACK. Under environmental impact, I notice you have thermal, chemical, and physical effects of the cooling system on the marine and aquatic biota. Have you looked at all at the impact on watersheds or waterbasins from water use for cooling large generating plants or any kind of thermal plant? What happens to the water? For example, how much water is used for the cooling tower in western Washington or California. How much gets out of any given area? Do we know if the water being used for cooling actually leaves the system?

Dr. LIVERMAN. Could I call on Mr. Slade?

Mr. SLADE. A very small part is evaporated. It is just a few percent. The remainder goes through the system. There are spray canals that have pretty much the same effect.

Mr. McCORMACK. What is the amount of water that the cooling tower of a 1,000 megawatt plant would require.

Mr. SLADE. It is on the order of millions of gallons per hour, but I do not have the exact information.

Mr. McCORMACK. That is quite a lot of water in terms of the system itself?

Mr. SLADE. Yes.

Mr. McCORMACK. Thank you.

Dr. LIVERMAN. We have studies at Hanford and Oak Ridge as to this issue. It concerns the local fogging problems where you have an inversion or a closed-in area. There could be considerable fogging conditions, depending on how much stays in the region or recycles.

Mr. McCORMACK. Are you studying this question?

Mr. SLADE. We have two kinds of studies. One is the individual cooling tower and what happens to it, such as fogging or icing. The second group would be studies of mass cooling towers, such as in nuclear energy parks where the effects are more dramatic. This is a new area of study that we are getting into.

Mr. McCORMACK. Thank you.

Mr. GOLDWATER. Where are you in regard to biological, physical, and oceanographic studies of the coastal zones?

Dr. LIVERMAN. Last year we initiated in the New York area off Long Island, a very large program through the Brookhaven National Laboratory involving various other agencies, particularly NOAA and the Department of the Interior. In 1976 we started a program in the southeastern Atlantic area. We are trying to get a small one started in the Gulf of Mexico and off the California coast. The budget asks for increases in the level of efforts in those areas. We are looking at biological and physical oceanography and the effects upon organisms where currents in the water are shifted or modified by the presence of a nuclear plant or a fossil storage facility.

We also have programs off the coast of Puerto Rico and around the Alaskan coast. It is a program that the AEC had in place for sometime. These programs are looking at where radioactive materials move, such as out of the Columbia or the Hudson River.

We are concerned with a very broad look at the base lines. These studies are pretty thoroughly integrated with and coordinated with the Bureau of Land Management's Outer Continental Shelf programs.

Mr. GOLDWATER. Are these studies in-house or contracted?

Dr. LIVERMAN. Most are done by contract with university groups and others. The programs are not in ERDA's major laboratories, and, there is the oceanography one which is conducted principally external to our labs.

Mr. GOLDWATER. In California our coastal commission works with universities and has completed some base line studies. In some areas they are very complete, but I am not sure about other areas.

Dr. OSTERBERG. The Scripps program is an old program. It began when they were testing nuclear matter in the islands. They saw evidence of radioactive water masses moving toward Japan. For the last 8 or 10 years the program with Scripps has been more of a basic transfer of material which has been directed toward the open ocean. In the last year, we directed it closer to shore. It is not so much base line, but we are familiar with the work being done by the southern California group. This is not the same area. It is looking at transfer material from food chains. It is what is happening there that counts.

Mr. GOLDWATER. You are interested in what is there?

Dr. OSTERBERG. Yes.

Mr. GOLDWATER. Are you duplicating anything that has already been done?

Dr. LIVERMAN. I don't think so. I think there is pretty effective coordination.

Mr. McCORMACK. I am sure you would not do that intentionally.

Dr. LIVERMAN. I think we have taken a pretty hard and deliberate look jointly with all of the people in the Government sponsoring R. & D. As Dr. Osterberg said, in the last couple of years, we moved into the areas that run from the immediate onshore out to 4 or 5 miles. This is where much of the fishery business is going. It is in that area where any modifications of the environment become critical. I believe we can say with some degree of confidence that there is no unnecessary or undue overlapping of the programs.

Mr. McCORMACK. I have a few more questions. Under analysis and assessment, there is the assessment of energy conservation impacts and alternatives in the Northeast. Is this a specific contract for one specific project? If so, what impacts are being studied?

Dr. LIVERMAN. Our Dr. Swinebroad that runs that program could perhaps help us.

Dr. SWINEBROAD. This is principally contracted with Brookhaven Laboratory. Now, in looking at alternate energy development schemes, such as the increased use of coal and the gas supply, it is a paper program that uses information that is already generated.

Mr. McCORMACK. Who is doing the study?

Dr. SWINEBROAD. Brookhaven National Laboratory.

Mr. McCORMACK. What are they looking for?

Dr. SWINEBROAD. They are looking at impacts of airborne pollutants and the use of water. They are looking at the social impacts.

Dr. LIVERMAN. I think that this is simply an illustration. It is not meant to be exhaustive, but as you may know, this was discussed in our budget program. We established in each of the seven major ERDA laboratories what we call a reasonable system analysis program. This one happens to be centered in Brookhaven.

Now, each of these labs specializes in different areas. The Argonne Laboratory is becoming a lead laboratory for a particular study on a national coal assessment, where we utilize all of the laboratories to address the questions related to the environmental health and safety impacts of coal and its full development. We are doing different kinds of studies in different laboratories to put all of the expertise together to address broad questions that demand this data. This study will take 18 months or 2 years. We, then, will move on to another area of study.

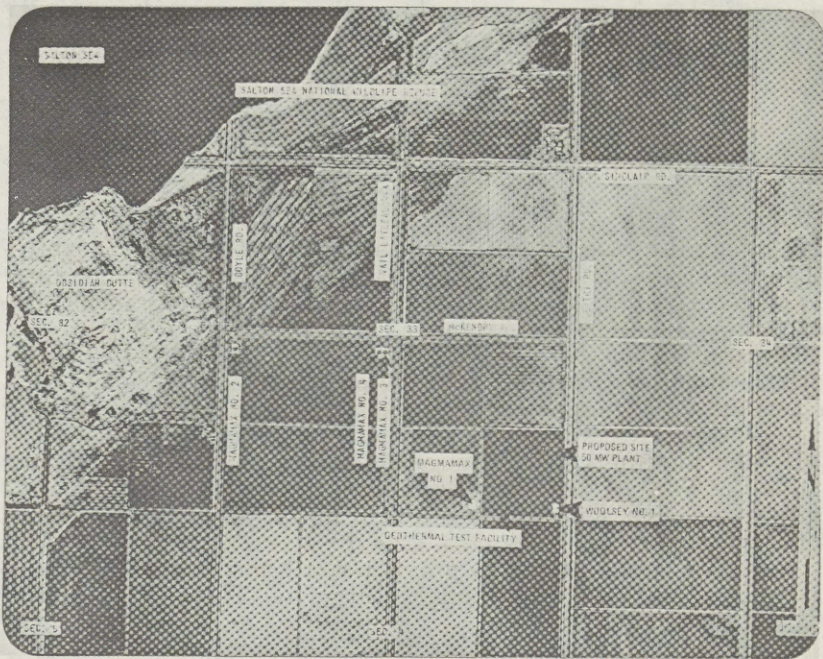
Now, we take into account the infrastructure of the communities where things may be carried out and the census and economic data that people are putting together. We take a look at the manufacturing that is going on, among other things, so that hopefully, we can provide better guidance to ERDA. We also would have available for the people in affected communities and States, the information that they need to help them make decisions about the programs. The Los Alamos Lab, in particular, is actually working currently with the Western Governors Regional Energy Policy Board so that they may have direct access to the total data base that Los Alamos is putting together on these issues.

We are exploring with them, how can we most effectively make this information available to State and local communities as well as for ERDA and other Government use.

Mr. McCORMACK. Please continue.

Dr. LIVERMAN. What I would like to do in the next 6 or 8 minutes is to run through a series of slides very rapidly to show you what we have put in place in the geothermal area in California. It is a program we started a year ago, as late as June of last year, and we did not have \$1 in place at that time. We went in jointly with the geothermal division and put in place a program where the environmental effects are considered along with the technology. We want to insure that geothermal resources are utilized in an environmentally sound manner.

The ERDA contract with San Diego Gas and Electric says that ERDA will sponsor the program and the pilot plant will be in operation around March. This is an overlay picture (slide 14) which shows the proposed 50 megawatt plantsite where the red spot is near the middle. Here is—at the Senate committee we had the actual model of this, this morning.

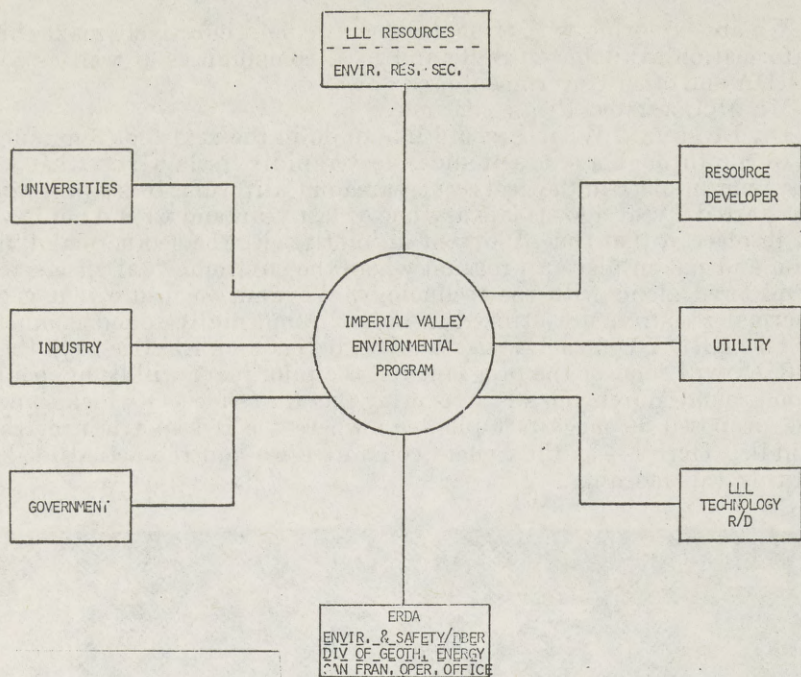


SLIDE 14

Mr. McCORMACK. We saw it last week.

Dr. LIVERMAN. I will go on to the next slide (slide 15). The environmental part of the program consists of work by universities, government, industry and the utilities.

The Livermore laboratory is carrying out the technology end and coordinates the whole program. As to the kinds of agencies involved,



SLIDE 15

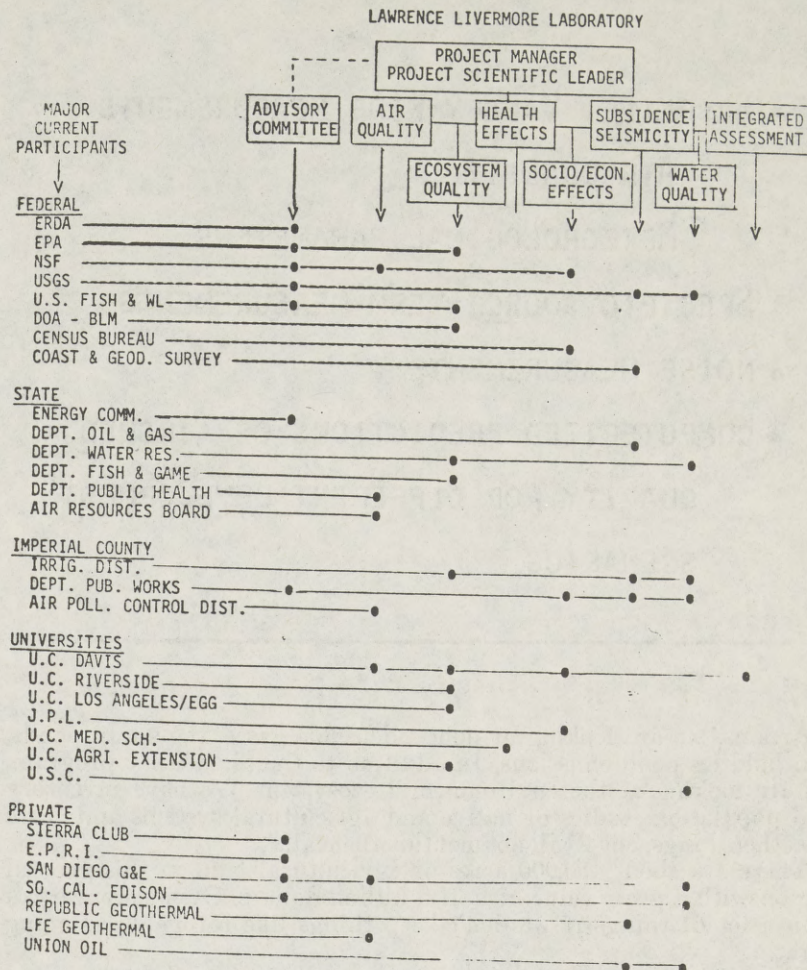
and I won't list them (slide 16), it has been a pretty effective involvement of all the Federal, State and local people, having any interest in the outcome of that program. There is an air quality program and one to investigate the noise aspects (slide 17).

This next slide shows the Niland site (slide 18). We have a monitoring station or stations around different areas to track closely what is coming out of the geothermal area. Next is a lettuce field being exposed to effluents. Next is a monitoring station (slide 19).

Here is another type of monitoring station which samples the air (slide 20). The kinds of things we are looking for at these stations are sulfur, ammonia, wind speed, and rain and/or any related kinds of information.

Next we have the air quality program which concerns wind velocity and other things we are collecting in that region. Through cooperative

IMPERIAL VALLEY GEOTHERMAL PROJECT ORGANIZATION AND PARTICIPANTS



AIR QUALITY PROGRAM

- BASELINE, VALLEY-WIDE MEASUREMENTS

AIR QUALITY

METEOROLOGICAL PARAMETERS

- SPECIFIC SOURCE-TERM MEASUREMENTS

- NOISE MEASUREMENTS

- COMPUTERIZED PREDICTIONS OF AIRSHED

QUALITY FOR DIFFERENT DEVELOPMENT

SCENARIOS

SLIDE 17

programs, we are looking at noncondensable gases, the spray ponds, and holding pond emissions. In addition to the air quality program, we are looking at the environmental ecosystem. We have inventory and population studies of native and agricultural systems and there are other things, but I will not mention them all.

There are about 450,000 acres of agricultural land in this general region with a gross value of half a billion dollars. Obviously, we can ruin a lot of things if we don't keep things like refuge areas going right.

This slide shows an experiment exposing lettuce to the geothermal effluent (slide 21). In addition, we have a health effects program. We are starting to determine what kinds of things may be occurring that could be of a health concern, particularly occupational health. We look at socioeconomic problems in the area and those that characterize the economy.

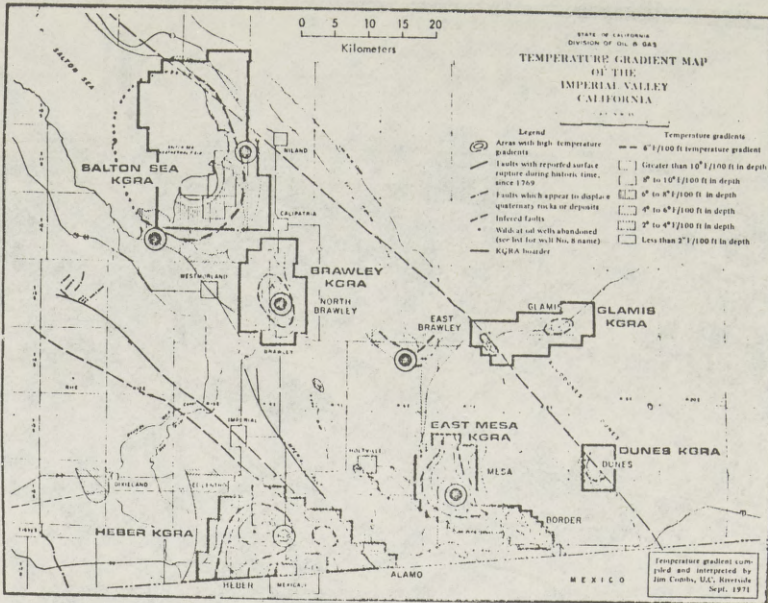
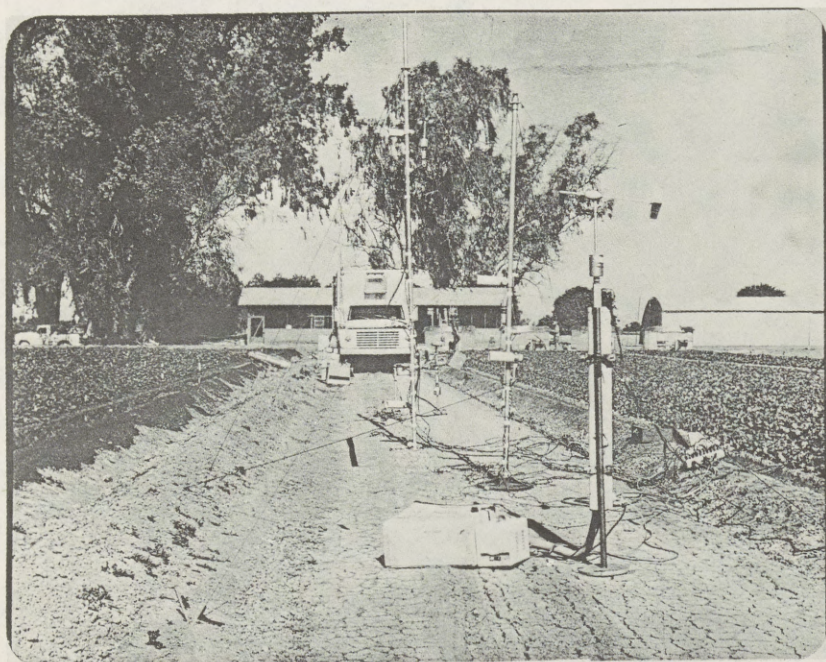


Fig. 1. ● - Locations of Monitoring Stations for Characterizing Pollutants and Meteorology.
(Map adapted from Palmer, *et al.*, 1975).

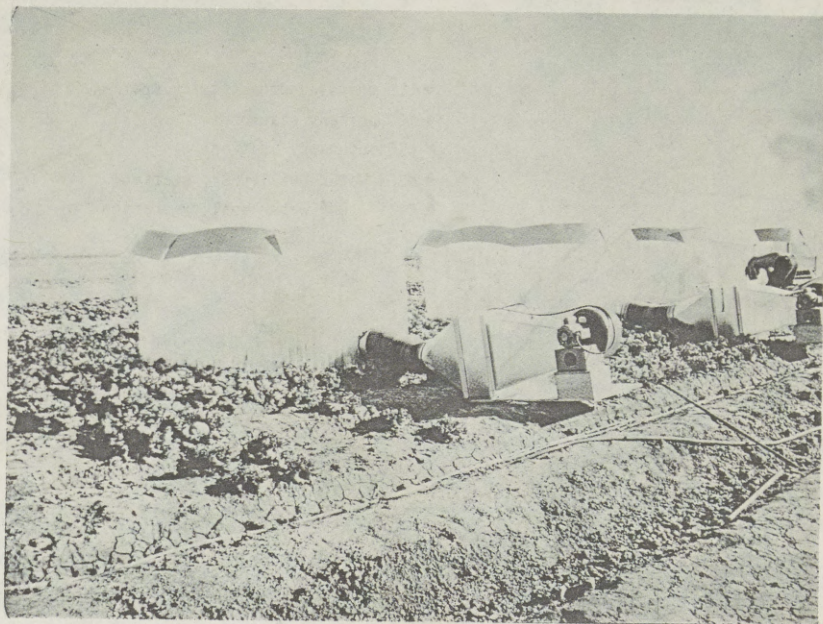
SLIDE 18



SLIDE 19



SLIDE 20



SLIDE 21

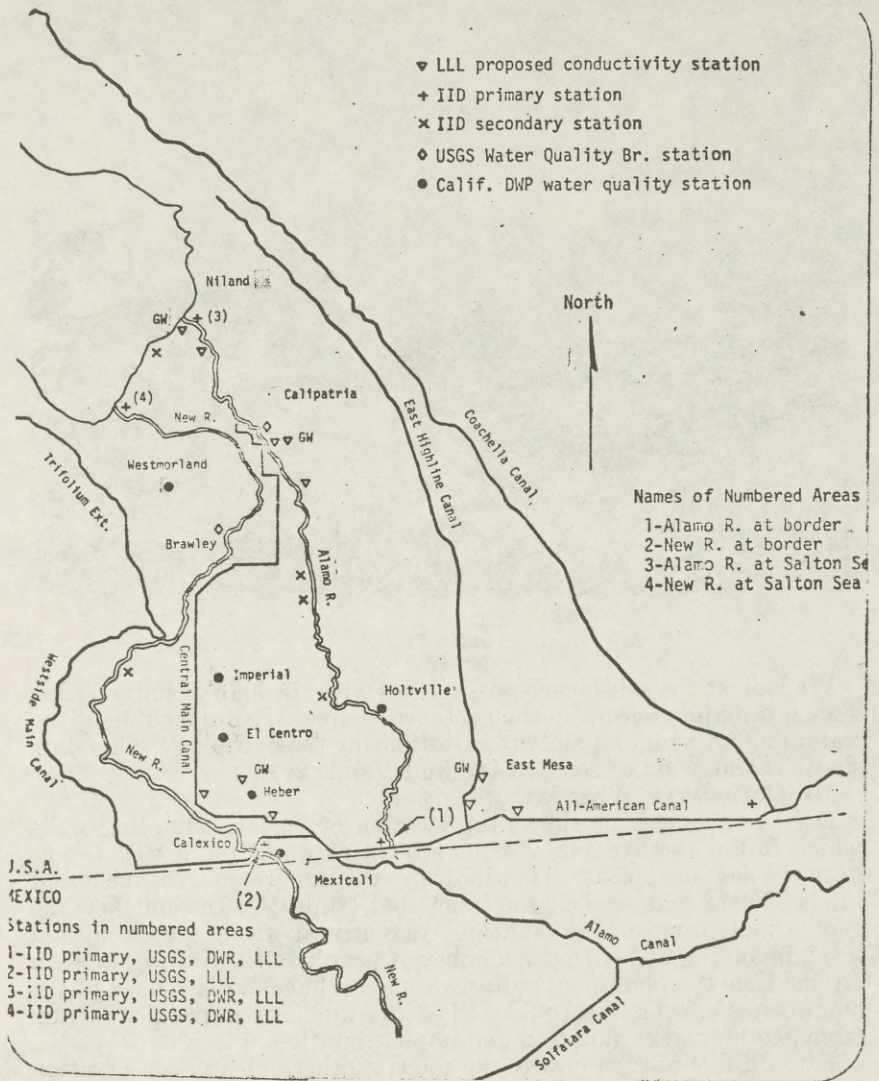
We look at the subsidence possibilities with the help of universities. This is a major concern in the geothermal area. We are looking at the water quality program and are investigating the hydrology. This slide shows the location of some of the wells (slide 22).

Mr. GOLDWATER. What is that?

Dr. LIVERMAN. This shows the location of various sampling wells which follow the hydrology or movement of water (slide 23). Let us have the next one, please. That indicates the integrated assessment and kinds of data that are being accumulated (slide 24). In summary, the geothermal program is operating currently at about a \$1.6 million level, involving an enormous number of people in the California area. By the time the plant goes online, we should have in place most of the monitoring efforts. We could follow the kinds of impacts resulting from geothermal exploration and implementation.

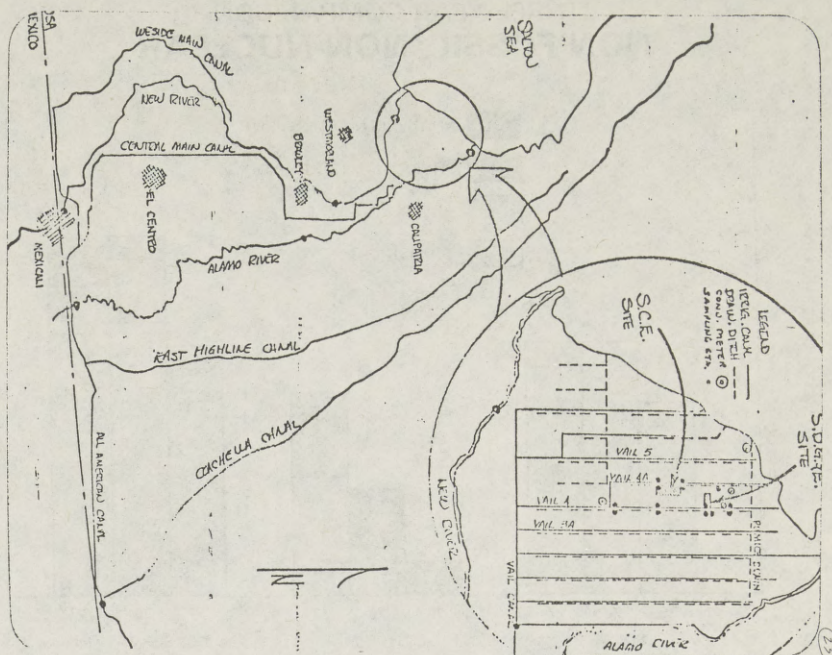
I would like to turn now to the solar, geothermal, and conservation areas. You can see that in fiscal years 1975 through 1977, the solar energy budget is holding fairly constant (slide 25). These have been programs that were inherited from the AEC. The question could be asked, "Why isn't the technology carrying some of these out?" It is a legitimate question. My only rebuttal would be that it takes a little time to do this.

We feel that the programs we have had in place have been good and substantial, but the direction will be changed. We have to be—or would like to be—in a position to do these things that are shown on



SLIDE 22

WATER QUALITY



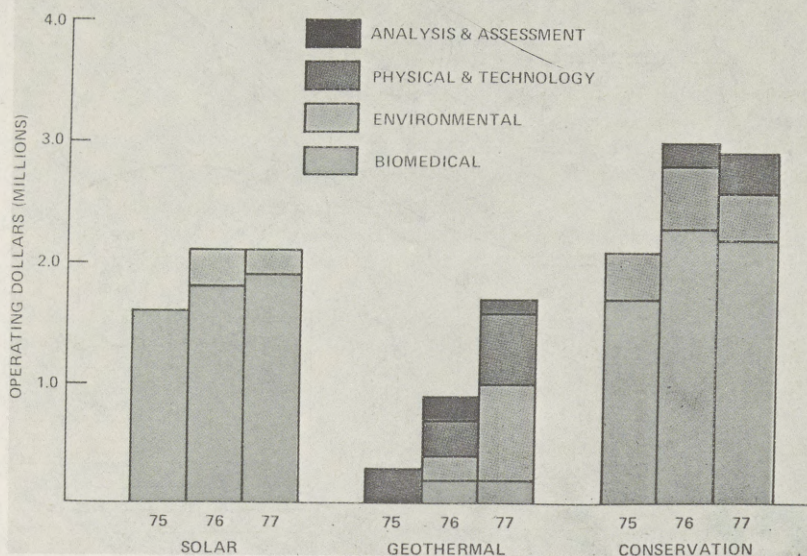
SLIDE 23

INTEGRATED ASSESSMENT PROGRAM

- ACCUMULATE PERTINENT DATA FROM OTHER SOURCES
- MANAGE DATA FROM THE MEASUREMENT PROGRAMS
- EVALUATE MEASUREMENT PROGRAMS FOR ADEQUACY AND RELATIVE PRIORITY
- CO-ORDINATE ALL MODELING ACTIVITIES
- EXAMINE REGIONAL QUESTIONS SUCH AS LAND AND WATER USE CONFLICTS
- PERFORM COST-BENEFIT STUDIES WITH REFERENCE TO CONTROL TECHNOLOGIES OR DEVELOPMENT OPTIONS
- PERFORM DATA AND ASSESSMENT TRANSFER FUNCTION

SLIDE 24

BIOMEDICAL & ENVIRONMENTAL RESEARCH THREE YEAR COMPARISON NON FOSSIL, NON-NUCLEAR



SLIDE 25

the following slide. We were able to get this process going on the ground floor. I think this serves as an example of how the environmental development plan and the working of the environment and safety areas can, in fact, effectively be done with the technology if you start at an early enough time. Now, Mr. Chairman, I think I will stop. I would be glad to try to answer any additional questions.

Mr. McCORMACK. Thank you very much. I would like to ask you to discuss for a moment the program of coordinating with States in these activities.

Today I saw the proposed budget for the California energy program. Much of it is in fields related to this. I am curious to know what kind of coordination program there is as far as the environmental impact and the societal impact are concerned? What are the States doing and what are you doing?

Dr. LIVERMAN. In the case of California in particular, I had two or three discussions with John Wiegles who went there to head the energy research and development program. We are in the process, as an agency, of writing an agreement with the State of California to have a more formal mechanism to coordinate efforts. In the geothermal project, there have been people from Wiegles shop in the geothermal area that have been involved in that program since its early initiation last year. They have been tracking with us, all of this. I don't have this with me, although I am sure that I could provide it. But we have encouraged our regional laboratories to become involved in this area. They are people who live in the region who could interact and get acquainted with the people in the State planning offices or State energy offices in each of the States in their immediate area.

I told you about the Los Alamos laboratory. They have working relationships with the Navajo nation and the States of New Mexico, Arizona, and Colorado, as well as a number of other smaller groups. This is to see how the information that they are gathering can be made useful to those people. In exchange, if the States or others are collecting information that can be incorporated into a broader base, this could also be exchanged.

It has been not through the activities of headquarters so much as the activities from the laboratories that we have been able to do this. As you are aware from having heard part of the synthetic fuel discussions last fall, we had a close working relationship for the last 4 or 5 months with 10 western States and the National Governors Conference. I signed a letter last fall going to all of the Governors of the 54 States and territories which asked them how they felt that we, in ERDA, could better interface with them and their institutions.

Also, if they had money they wanted to put into a joint program, how we could better put our dollars together to achieve a common end. We are in the process of working with this. I heard it said this morning that five other State groups are being worked with to tie down formal agreements for this exchange group.

Mr. McCORMACK. Are you going to establish a formal mechanism in your shop for working with each individual State or region?

Dr. LIVERMAN. I guess that we have not thought completely through whether we will establish this mechanism with every State. It is evolving in that direction. I suspect by the time I return next year, we will have several agreements with the States or with regional groups or contacts that people are working with in the States.

Mr. McCORMACK. Judging from what I saw of the California budget, it is quite substantial. There are areas where they might handle projects as well as you could. Environmental impacts might be an example.

Dr. LIVERMAN. In that particular case, we have encouraged the Livermore Laboratory group, the focal point of our funding, to put together a package for this region that makes sense, if there is loose money in the California budget. Then we would find the money to support the package. They are there. They know the problem. That is why they should be put into a steering-type group.

Mr. McCORMACK. How are you interfacing with the EPA or other Federal agencies, in research and development for energy related areas?

Dr. LIVERMAN. In the case of EPA, we have a very fine working relationship which evolved over the last 2 years. The Assistant Administrator for research and development and I have lunch together periodically. Our staffs work rather closely together. They are passing through to us and other agencies about \$50 million, \$12 million to ERDA with fiscal year 1976 being \$6 million. We have periodic meetings of the staff and technical meetings. We had one in North Carolina a few weeks ago of the health researchers doing work in health effects of energy effluents. There were about 150 people sponsored. Principally by four agencies. We sat down and went over the actual research and development that people carry out.

As I mentioned we are pulling together the total research and development package in the environment and safety areas as related to energy. The second thing is that we found very favorable cooperation from all agencies. The material is fed back to them and we go about seeing whether or not there are any unnecessary overlapping programs or if we should have joint programs or not.

I think you will see evolution taking us toward joint programs, particularly in the occupational health areas.

Mr. OTTINGER. Would you yield?

Mr. McCORMACK. Yes.

Mr. OTTINGER. Could you give us the specifics of how your activities compare with those of EPA, such as who does what on a specific program. I am particularly interested in solid waste.

Dr. LIVERMAN. Solid waste is not my area. I sat through the meetings, however. It is Mr. Heller's area. Now, EPA has the major thrust. They are in the process of working out a specific detailed interagency agreement. It is a major effort of EPA. The urban waste area is not such a major effort of ERDA.

Mr. OTTINGER. In each of the areas where there is overlap, are you going to work out a specific agreement on who does what?

Dr. LIVERMAN. Yes; in my own particular area, it is easier said than done, because of the health and environmental objectives and the different objectives of the research. The second option is, not so much to decide precisely who does what, at least in my opinion, but to collectively, between us, insure that we are not carrying out work that is overlapping. It will be difficult to define. It will vary from program to program.

Mr. OTTINGER. I am also concerned about work not being done. I feel it is——

Dr. LIVERMAN. You have expressed my concern. One of the reasons that I continue to plead strongly before Mr. Brown's subcommittee, that ERDA should have a responsibility in the environment, health and safety areas relating to energy is to determine two things. One of these is what people are not doing. Are there voids that are not being filled by somebody? We found in our first gathering of the information that it simply was not being gathered in fine enough detail to tell us if there were any scientific areas that were not being covered adequately. The second questionnaire is much more detailed. It will be able to tell precisely the answer to the question which is: Are we not covering areas that are important?

Mr. McCORMACK. Is anybody overseeing the total situation? We do not have just EPA and ERDA, but we have the NRC and the Depart-

ment of Labor. Is there any sort of coordinating agency or is any person designated by the Administration to coordinate or oversee this situation?

Dr. LIVERMAN. I don't think you will find that a particular individual or a particular agency has been designated to handle coordination. The thing I am trying to achieve, with full cooperation of the 17 or 18 agencies in the energy related areas in environment and safety, is to use the material that we are pulling together as a means of coordinating. We will sit down around the table and insure by discussion that we are covering things that need to be covered. In the energy related area of environment and safety, I am trying to see that this gets done.

In the broader environmental area, it is the CEQ that has the responsibility. Also, EPA feels it has a strong responsibility.

Mr. McCORMACK. How would you feel if CEQ was the coordinating agency?

Dr. LIVERMAN. It would not trouble me particularly. I would have to reflect on the level of their resources, both manpower and dollars. That is, if they were the Chairman of the Board, they probably could then achieve it, but the gathering together of information and the incorporation of everything that is good, takes manpower resources and dollars. I felt it was ERDA's responsibility. We have to come up with a national plan. The only way I can do this is if I know what everybody else in town is doing in this area. This is why I felt the heat on the back of my neck to do this. We have to insure the research and development needed in the environmental and health areas as related to energy get done. We can't afford to guess.

Mr. McCORMACK. I agree. I think that is primarily your responsibility.

Mr. OTTINGER. Can you give me a better idea of who does the research work in the environmental area, that is, as concerns the various divisions of ERDA itself? For example, in your solar heating and cooling program, who actually contracts out for the research with respect to environmental effects of this? Do you do it yourself? Is it in your budget or the solar energy budget?

Dr. LIVERMAN. It is principally done by me. I would say that in the health area, yes, I do this for everybody. The kinds of environmental dollars that you will see being carried in the solar budget, the fossil energy budget, or the geothermal budget, is not a fundamental underlying program in environmental health and safety. The environmental area of the technology programs contracts out to have people collect information they must have to go into environmental impact statements. That is not principally the generation of new information. It is the gathering of that which exists.

It is my responsibility and I don't think there is much challenge within the agency on this issue. We are in the process of determining who is generating the original information and looking at the environmental effects. It falls largely under my general purview. As I mentioned earlier, in discussing our environmental development plan, we will, jointly with the technology, lay on the table all questions about either technology or the environment that have to be answered. It is not so much a question of who supports it, but we must know what must be done. Knowing that, then we would argue about who does it or collectively, we would put up dollars to see that it gets done.

Principally, I worry about it but also do they.

Mr. OTTINGER. Specifically, referring to the \$3 million in the solar budget for technology support and utilization for fiscal year 1977, is there money for environmental studies as we understood that there was? I wondered how that related to your activities?

Dr. LIVERMAN. I have not examined that particular section of the solar budget in detail. At the time that our budget goes through the Budget Review Committee, members of my staff go through the budgets of the technologies to see if there are issues that are arising, or if there are questions in those programs that we should address ourselves. I would be very surprised if there are not some dollars in this figure that would address an assessment of what would be the likely environmental impacts of solar activity.

Mr. OTTINGER. I am not sure that it is not a good thing. I want to make sure there is a real understanding in the agencies. I think it is very hard to separate out the environmental aspects from the technology research activity and put it in a different spot. In many cases, you ought to be the supervisor to make sure this is being covered.

Dr. LIVERMAN. Yes; I think the reason for giving the detailed example in the geothermal area, is that I believe it is thoroughly agreed between Dr. Willis and myself where our areas of responsibilities are. We continue to talk to each other and I think our geothermal project is the farthest advanced in coordination. Now, as to solar energy, we have not quite reached that degree of discussion between us. Since our major budgets are interfaced with the fossil people, we are spending a lot of time getting our programs in this area interfaced because we have major needs and limited dollars.

We are going to try to come up with the answers to your concern by putting my programs together with the technology. Then, we know what each of us is doing and we know what is to be done.

Mr. OTTINGER. That leads to the next question. Are occupational health and safety studies being done with respect to each of the research technologies within ERDA and are you overseeing them?

Dr. LIVERMAN. That issue is up for discussion right now. I think the answer to that question lies in this example. Regarding the fossil case, Phil White and I had discussions about what I thought my responsibilities were in these areas. He agrees with the fact that I should be the man in the Government, as opposed to HEW or somebody else, to put into place the occupational health and safety programs in the various fossil plants, while, also involving the other people at the same time. Since it is ERDA's program jointly with the industry, about the only place you can orchestrate this is from the ERDA side, while involving the other people in the overall program. We are trying to put that program together.

Mr. OTTINGER. It is still a little vague. Let me be more specific. There are a lot of occupational health and safety problems which we are aware of in the synthetic fuel programs. What specifically is the agency doing? Who is doing it? What is the timeframe?

Dr. LIVERMAN. We are not doing it this instant. There is no synthetic fuels program. We are in the process of formulating or defining what those programs should be. You have a series of different kinds of processes.

Mr. OTTINGER. We have a \$6 billion proposal here, do we not?

Dr. LIVERMAN. It is \$2 billion. It is a synthetic fuel proposal.

Mr. OTTINGER. Is part of the \$2 billion to carry out studies?

Dr. LIVERMAN. I believe that Mr. Fri said this morning that funding for operational activities will come out as a 1976 supplemental. It will take care of what you are talking about. It would handle the community impact studies as well.

Mr. OTTINGER. I do not want to do away with this. I just want us to be aware of it.

Dr. LIVERMAN. I guess the direct answer is that we have not yet designed those programs. It will take a considerable amount of design because you are dealing with a limited number of people with different exposures. My guess is that actually the design alone, or the kind of study put in place to insure you are getting meaningful information, is a 3 to 6 month study. It will cost about \$300,000 or \$500,000. You need the best people or best minds that you can get.

Mr. OTTINGER. Is that in somebody's budget?

Dr. LIVERMAN. It is not in my budget now. It is in the supplement that is coming up.

Mr. OTTINGER. I think for each of the technologies, particularly where there is a warning flag, that this should be noticed.

Dr. LIVERMAN. Yes.

Mr. OTTINGER. This could be harmful to people. I think this is a must.

Dr. LIVERMAN. That is right.

Mr. OTTINGER. You mention an assessment of energy conservation impacts in the Northeast.

Dr. LIVERMAN. Yes.

Mr. OTTINGER. Con Edison has proposed burning a much higher sulfur fuel in New York City.

Dr. LIVERMAN. Yes.

Mr. OTTINGER. Do you have any studies underway to assess the health and safety impact of such a decision?

Dr. LIVERMAN. Yes. We got caught up in the lowering of the standard by EPA last fall. The Brookhaven group, in their environmental and health assessment program, has addressed this question for some time. Now, in addition to their assessment of what the sulfate impact might be, we have a number of laboratory experimental programs that are looking at the effects of sulfur. EPA has this also. I don't know the specific answer.

Mr. OTTINGER. What are you getting for answers on it? I am repeatedly asked as to whether this is a sound thing to do, because my people suffer under high utility rates, the highest in the country. Am I to say that it is all right, that it is safe? I have to have an answer to these questions.

Dr. LIVERMAN. I will call on Dr. Carter. He runs our medical program.

Mr. McCORMACK. Go ahead.

Dr. CARTER. You certainly identified the problem that we recognize. The urgency of this particular problem, I think outstrips many other considerations. The EPA maintains a relatively large research effort in human health and, in particular, in the epidemiological studies. We have tried, as we developed our programs, not to duplicate what is going on in the EPA, but to carefully communicate our plan-

ning with EPA, in such a way that we can address the high priority issues in an orderly, well planned, and efficient manner, rather than charge into the area and try to overlap.

Now, after saying all of that, I think that the existing programs in this country to assess the particular problem that you are concerned with is inadequate from our point of view. Our—ERDA's—point of view is more toward the developing technologies than to the existing technologies or the utilities in New York City or the resultant pollution problems.

However, when you get right down to the crunch, the problem that we are concerned with say in—they also evolve about your questions, such as those that are tolerable or acceptable levels of sulfate. Our approach is different in terms of our particular technology orientation. But ultimately, the questions are the same.

The problem that we are addressing is the one that Dr. Liverman had emphasized. It is the necessity for several agencies to develop a coordinated approach to this which meets all of our needs, and at the same time, addresses the critical problems of safety.

Mr. OTTINGER. My time is obviously up. I thank you. To whom do I go for an answer?

Dr. CARTER. I think you are right to come to us and demand an answer. I think, in coming to us, that you are only coming to one component of a very complex problem, but we should be capable of providing direct answers to the direct questions. As Dr. Liverman said, at this stage of the game, we cannot give direct answers. But we recognize we are going to try to answer this. We are doing our best to move toward getting the answers.

Mr. OTTINGER. Do you have enough money in fiscal year 1977 to do this?

Dr. CARTER. Dr. Liverman will defend the budget or the figures. I only speak as to the general problem that occurs in the United States. I believe the general effort is inadequate. Insofar as we share in that general effort, I think we also share some responsibilities for inadequate performance.

Dr. LIVERMAN. May I comment?

Mr. McCORMACK. Yes.

Dr. LIVERMAN. We have a program called MAP3S, the Multi-State atmospheric power pollution program. We follow the injection of a pollution stream in the air from coal fired plants in the Midwest as it moves over New York City. It is not clear to us at this point whether the burning of high sulfur coal in New York has much to do with the amount of sulfate in New York City. It is possible that that blows out into the Atlantic.

Mr. OTTINGER. It blows over my district. That is what I do not like. There was a big article in the New York Times explaining that suburbanites thought they would go home to clean air, but they are getting all of New York's pollution. That is Westchester County and southern Connecticut.

Dr. LIVERMAN. That is precisely the issue. That is what this program is meant to demonstrate.

Mr. McCORMACK. If they move into New Jersey, they would obviously get away from that.

Mr. GOLDWATER. That is probably the same problem we have in Los Angeles. It blows around and settles there. I hope it is solved fairly

soon. Now, I want to thank you, Dr. Liverman, and your colleagues for taking the time to come up to the Hill and discuss this with us. This is an important area of concern in any of the projects that we are undertaking.

Now, our interest is primarily in solar, geothermal, and conservation. I am a little disappointed that we are relegated to such a small portion of the budgetary pie; 4 percent out of some \$170 million. We feel that those areas are very important and perhaps deserve more emphasis on your part. Maybe you have an explanation for this, and I would be interested in hearing it.

Dr. LIVERMAN. I suppose the explanation is that, I agree with you, it would be desirable to have more support in geothermal, solar, and conservation. Within the agency's priorities of stressing fossil fuel and nuclear, we have had to build very rapidly in those areas. As I pointed out in geothermal, we decided that because we were on the ground floor we would have to penalize other areas if necessary to get that program going in a timely manner.

Now, in the context of the total budget priorities and the budget that I received, we ended up with what you described. It is perhaps an inadequate base and it is of particular concern. I make another observation. In the multitechnology area, there is quite a bit of activity that is related to the activities of the subcommittee. It would require considerable and detailed examination in that area in order to make this clear.

Mr. GOLDWATER. In your earlier testimony before this committee, at the time that Dr. Seamans was here, you talked about a fully integrated systems approach to all areas of energy.

Dr. LIVERMAN. Yes.

Mr. GOLDWATER. Now, OTA has criticized the program for not including the integrated systems approach. In your 1977 budget, will you be doing more of this?

Dr. LIVERMAN. I think as I said, the geothermal project, in my view, and I think in their view, has become a pretty well dovetailed and tied together, integrated package. The safety and health factors are tied in a meaningful program. We jointly defined what it was we needed to know. We are trying to do this in the fossil area. We have not reached that stage with solar energy or conservation. We are moving rapidly to put in place a well-thought-out environmental development plan for each technology.

Mr. GOLDWATER. When do you think you will have this put together?

Dr. LIVERMAN. I hope by the end of this fiscal year. We are shooting for doing this as rapidly as possible. My guess is that it would be at least November before we have this in place. I am not convinced that it will all be wrapped in place even by that time. We are working as a top priority task to achieve this.

Mr. GOLDWATER. It seems to me that you are not too aggressive in this area. Is it due to the lack of enthusiasm in various parts of the Administration? Would it be that difficult to implement this kind of integrated approach for geothermal and solar energy? Those programs are defined a lot more clearly than they were last year. It would seem to me that you are behind in this as far as getting into those programs on an integrated basis, at least in the beginning. We are not playing catchup ball at this time.

Dr. LIVERMAN. I think your description is correct. I am actually playing catchup ball.

Mr. GOLDWATER. You don't think you will catch up until next year?

Dr. LIVERMAN. As I mentioned earlier, Dr. Seamans approved a reorganization in my shop. I have been granted an additional 25 positions to get people to put these programs in place. That will allow us to describe for others and ourselves in considerable detail what the programs should be.

Mr. GOLDWATER. Are you short of people?

Dr. LIVERMAN. I have deliberately not hired people until I could decide precisely what is the best way to perform the interface. I have run a few experiments. It seems the approach to the geothermal program has been the right one. Now, having described the program and hearing it put on the table just defines the problem. From there, you have to seek the necessary resources to carry it out.

Mr. GOLDWATER. What is the total number of people in your shop?

Dr. LIVERMAN. The people I am talking about are headquarters-type people. They are civil servants. I think I have a total in four divisions of perhaps 350 with 25 additional authorized. Our work is carried out totally, almost totally, by a contract or contracted-type activities. The number of personnel is not the limiting factor. It is the operating amount of money for the laboratories and the contractors.

Mr. GOLDWATER. You have 350, with 25 additional authorized? Will those 25 more likely go into solar or geothermal?

Dr. LIVERMAN. Yes; solar, geothermal, fossil and conservation.

Mr. GOLDWATER. I think that is a fairly important matter that is aside from the work that you are doing. It would be important to integrate it with those programs. Obviously, there are going to be failures and problems that will depend upon your expertise to solve or at least to recognize. I hope you proceed on this.

Dr. LIVERMAN. Yes; Dr. Seamans signed a piece of paper Friday and we are recruiting tomorrow.

Mr. GOLDWATER. Would your program provide the absolute minimum effort that is required to support the solar, geothermal, and conservation divisions in effectively implementing the plans and requirements including the environmental impact statements?

Dr. LIVERMAN. They provide funding for their own environmental impact statements. I guess an unqualified, direct answer to the question is that the budget we had in 1976 in solar energy, which had not increased in 1977, would be judged as an inadequate budget.

Mr. GOLDWATER. It is a very serious problem that arises at almost any level of Government. Are you assessing the environmental impacts or the requirements at all?

Dr. LIVERMAN. Yes; in the assessment programs. With the additional people, we will define this far more precisely. We have put in place what we call a balanced program planning effort. I forgot which of our laboratories is taking a cut in putting the solar one together. They will be working with the technology people to help define in a precise and detailed manner what the requirements are. In 1978, by the time that budget comes to the Hill, we should know precisely what is needed. If it doesn't get there, the technology will be slowed down. That is precisely the kind of answer I think you and we need.

If you don't put it on the table, you can't go the next mile. It could be technology or environmental R. & D.

Mr. GOLDWATER. Would it also apply to fossil and nuclear as well?

Dr. LIVERMAN. Yes; I think you recognize precisely what is needed. There should be a close working relationship so that both the technology and the environment, health and safety concerns are locked in place. They both have to go together.

Mr. GOLDWATER. As to geothermal or solar, are you precisely addressing yourself to these environmental obstacles?

Dr. LIVERMAN. In the case of geothermal, yes—particularly in the Imperial Valley. We do not have in place certain other programs. But, as to Imperial Valley, it is our judgment that the program is a pretty well-rounded, adequate program.

Mr. GOLDWATER. Are you looking into the possibility of earthquake inducement from reinjection or extraction of geothermal volumes?

Dr. LIVERMAN. Yes; the subsidence and the seismic activities.

Mr. GOLDWATER. How about electrical transmission of high voltage, such as the high electrical effects and discharge?

Dr. LIVERMAN. We have some biological and health related activities that address that question. It probably affects the fusion program or the high electrical fields research just as well. I don't know the level of that activity offhand.

Mr. GOLDWATER. What about possible toxic substances emitted from the fuel or the waste?

Dr. LIVERMAN. We have in place a program jointly with EPA at the Ames Laboratory in Ames, Iowa. They are burning urban waste. We are monitoring the toxic materials that are coming out. We are then studying the question of how toxic they are. At Oak Ridge we have a multitiered screening system looking at bacterial systems, in mice, in human cells in culture, et cetera. As to chemical compounds that cause cancer or mutations, we are looking into this. We run the compounds through a test to determine if they are toxic, at what levels they are, and what we have to do in terms of technology to prevent their release or to detoxify them. This is where you get into the multitechnology area. This applies to fossil and geothermal and to the solar components as well.

Mr. GOLDWATER. What are other areas you think you should look into as far as geothermal and solar are concerned?

Dr. LIVERMAN. There are three or four other kinds of activities in the geothermal area. We should be involved from ground zero with the technology people as they begin these explorations. That is to get the environmental and health and safety information needed so that we are not caught without having this done. There is the question of subsidence and the reinjection and such things.

Mr. GOLDWATER. There is something that disturbs me. I noticed it in your testimony on page 5 and again on page 11 also on page 13 that you talk about the deep sea diving medicine. There were 27 deaths related to energy or related diving activities.

Then on page 12 or on page 13, you talk about training for the oil spill cleanup and prevention.

Dr. LIVERMAN. Yes.

Mr. GOLDWATER. You also talk about coal and slurry pipelines and so forth on page 11. I would first question whether this is a legitimate con-

cern of ERDA, and secondly, whether in fact, there are not other agencies or institutions that should be looking at this instead of ERDA. If so, why could these same dollars not be put to a different priority effort? Specifically, to offset the very negligible emphasis that you place on solar or geothermal.

Dr. LIVERMAN. I think paragraph H in the Nonnuclear Energy Act places on ERDA a charge to be concerned as with oil spills. We instituted this small effort in conjunction with EPA and others. This was because it was clear there were not enough people being trained in the cleanup of oil spills. There was inadequate manpower in that area. It seemed to be of enough concern to initiate this small effort.

Now, as to the question of the coal slurry pipeline, this is an area in which it is not clear who has the total responsibility. Regarding the movement of energy resources, with a small effort, we are trying to look at any sorts of things that look like they may prevent the full utilization of the resources. You could argue that it is an ERDA responsibility or somebody else's responsibility. It is sort of looking over the shoulder.

For instance this was a Bureau of Mines responsibility to be concerned with uranium mining once and I find I am the one sweeping the stuff off the street and doing something with it, not the Bureau of Mines. If it is a health problem relating to atomic energy, then these matters can be viewed as a concern with energy. As to deep sea diving, it is a particular point which, if one goes into the fossil energy area, and if you go into putting a plant on the floor of the ocean 1,000 feet under, you have workers that one has to be concerned about. Before we ever got into this, we looked across the spectrum of who was doing what. The Navy is not worried about it. They are worried about operational questions that don't involve diving of this nature. One might conclude that NIOSH would be worried because it is an occupational health problem. They have other things of a much higher priority to worry about. We found only one agency in Government that had a real interest in this. This was a group from NOAA. They have the expertise in their marine programs. Jack Thompson, of NOAA, and I discussed the fact that we had to look at this matter. We wanted to have a study done to define what type of program the Nation needs. Then you try to find somebody willing to put money in to explore this.

You find there are not very many people that are interested. We felt it was a high priority because of the extreme risk involved. That is if you judge by the number of people that are killed, it deserves some support to explore the establishment of rules as to why people die or the reasons. It is a question of judgment as to whether these are high or low priority. In our case, we felt the diving issue could have some major impact on energy.

Mr. GOLDWATER. These particular areas that you mentioned are obviously important. I am concerned about anyone that is being lost or killed, but doubt could be raised as to whether this is a legitimate area of concern for ERDA in the area of environmental safety. Now, in my mind and I would hope in your mind there is no doubt you do have responsibility for solar and geothermal. You are short of money and manpower. This is the point that I am trying to make. I would like to see a little more effort put in these areas. Thank you.

Mr. BROWN (now presiding). We have a large scuba diving club on the Hill. Go ahead, Mr. Wirth.

Mr. WIRTH. Thank you very much for all of your help, specifically on the Colorado question which has been a problem for some time. I wanted to ask you a question related to the point you made about an hour ago about working with the States, say in the plutonium standards. Do you work with States to develop plutonium standards?

Dr. LIVERMAN. That is not ERDA's responsibility to come up with standards. We are working with the States and with EPA to provide our data and technical expertise as assistance to them.

Mr. WIRTH. What happens if it is EPA's responsibility? You work with the States. What happens when a State standard in the area of a nuclear facility is higher or more rigorous than the Federal standard? That is, what if the State standard is more restrictive? What does ERDA do?

Dr. LIVERMAN. I think the thing we have done in this particular case is that we do not believe that the scientific underpinnings for the standard are there. We don't believe that they quite exist to justify pushing the standard to the level that it has been pushed.

Mr. WIRTH. Therefore, more research on plutonium standards has to be done by EPA?

Dr. LIVERMAN. No; it has happened that it has been done more by ERDA. We have a concern now. We had it then. We started the program of trying to relate a concentration of plutonium in the soil as opposed to the air. This was done to relate it to any reasonable dose one could expect to get. Therein then lies the problem.

The calculation was that with the original proposed 0.2 DPM per gram of dry soil, you would have to inhale something like 80 kilograms of soil to get a sufficient dose to create a problem. It leaves you with a nonproblem.

Mr. WIRTH. We have to get this sorted out so that there is a standard. What is the timetable for the development of the standard for plutonium in the soil?

Dr. LIVERMAN. EPA started having hearings on this in December 1974. Those are continuing. Our studies are continuing also. They are talking about having sometime this summer, a preliminary idea of a standard.

Mr. WIRTH. Are you doing the studies?

Dr. LIVERMAN. Most R. & D. work is being done by our laboratories.

Mr. WIRTH. Do you have enough funds to do it adequately?

Dr. LIVERMAN. We could always use more money, but I don't think those studies are underfunded.

Mr. WIRTH. Considering all the complaints about safety and reactors, I think this is more important than it was a year ago when we first talked about Rocky Flats.

Dr. LIVERMAN. It is crucial because it is difficult to define.

Mr. WIRTH. Will that standard be in draft form by EPA this summer?

Dr. LIVERMAN. It would be a guess. I could not speak for EPA. We have discussions with them at the technical and staff level. I think that they are coming to a decision as to whether they would try to implement a soil standard.

Mr. WIRTH. I sometimes think I am pushing a piano upstairs with a rope.

Dr. LIVERMAN. I don't think you even have the rope in your hand.

Mr. WIRTH. I feel that the piano is coming back down the stairs on top of me.

Dr. LIVERMAN. It is a difficult question to get an answer to.

Mr. WIRTH. I hope you would push EPA, knowing how important it is to one of ERDA's missions. Also, are there any parallels to the Rocky Flats situation elsewhere, say a nuclear installation reputed to be polluting the area around it?

Dr. LIVERMAN. The thought has been expressed that there was a lawsuit relating to the reactors at Hanford. I believe Congressman McCormack could speak better on this but the gist of it was if you are going to run these reactors beyond 1977, you are going to have to put in an ion exchange column to remove some of the radioactive releases.

Mr. WIRTH. What happens if there is some evidence that a nuclear powerplant is polluting areas on the outside? Is the power company held responsible for this? Who pays for this?

Dr. LIVERMAN. I think in general the power company is held responsible. I think the arguments arise as to how much pollution is there or is it within standards? If it is within standards that are set by the regulatory commissions or the EPA and there is no danger, then they would continue to have this pollution. If they exceed the low level release, they could be shut down.

Mr. WIRTH. Let me get down to the specifics. As you know the nuclear installation at Rocky Flats, which has been there for some time, produces emissions. Whether or not they are above your standard or the State standard is not important.

It is perceived by the community as a problem. There are people in that community that have been there for generations, on farms or ranches. Suburbia encroaches upon that area. Many people there would like to shift the use of land from farming and ranching, which is no longer economical due to the tax burden, to subdivisions. The county has the responsibility to zone the land, but they feel it is dangerous and will not permit rezoning. Consequently, these people are in a difficult situation. It would be amusing if the people were not suffering from it. It would be a catch 22 situation. They inherited the land and they are paying increasing taxes on the land.

They cannot subdivide or sell it. In some cases this land has been in their family for generations. Who is responsible for the pollution?

Dr. LIVERMAN. I think you are in a legal area. I have no such expertise. There is a matter of judgment, the Jefferson County public health officials say, "It isn't safe." In the judgment of others, such as EPA it is not a hazard. Now, in the judgment of people that are stuck with the house, it is a damnable situation.

Mr. WIRTH. These people cannot sell the land or rezone it. They have an immense tax burden. Why is Uncle Sam not responsible?

Dr. LIVERMAN. I am not in a position to make that judgment.

Mr. WIRTH. Is there not some procedure for such a situation? If it exists at Rocky Flats, it has the potential to exist at any other nuclear installation in the country.

Dr. LIVERMAN. I think that in the judgment of the Colorado Department of Health or the EPA, the land does not constitute a hazard. In the judgment of the Jefferson County medical officer, it does constitute a hazard. There are people caught in the middle.

Mr. WIRTH. They happen to own the land. They are hurt by this. These are factors over which they have no control.

Dr. LIVERMAN. If I were a landowner in that position, I would try to take it to court to get an answer.

Mr. WIRTH. Yes; they say you are our Congressman, what will you do? The EPA said that it is probably safe. If you go to ERDA, they say that it is not their responsibility. That it is a judgment factor. If you go to the State, they say it is a county concern. They say go to the county health officer. Then he refers to the fuzzy-type standards. We keep chasing our tails. In the meantime, these people are going broke.

Dr. LIVERMAN. My opinion is not an agency position.

Mr. WIRTH. What is the agency position?

Dr. LIVERMAN. I am not sure they have one.

Mr. WIRTH. Could we leave the record open for asking ERDA to fill this in as soon as possible? It seems to me we have to have some kind of procedure, not just for the Jefferson County people, but others. This may apply to other situations around the country. Can you generalize about this situation?

Dr. LIVERMAN. It is a far broader issue, whether it is Rocky Flats or another matter.

Mr. WIRTH. How are people recompensed for this when they have truly been damaged by the impact of the Federal effort, whether it is oil shale or whatever it may be?

Mr. BROWN. Could you provide a comment?

Dr. LIVERMAN. Currently there are at least three lawsuits alleging a total of approximately \$36 million in damages to landowners around the Rocky Flats plant which have been filed in Federal district court in Denver against the United States and against Rockwell International and the Dow Chemical Co., the present and former contractors at Rocky Flats. Administrative claims were filed pursuant to the Federal Tort Claims Act with ERDA prior to the commencement of two of the lawsuits and after the commencement of the third lawsuit. In all three cases, the administrative claims were either denied expressly by ERDA or were deemed denied—at the option of the claimant in accordance with the Federal Tort Claims Act—after 6 months elapsed without a final agency determination on the claims. After the lawsuits were filed, the Department of Justice, through the U.S. attorney in Denver, entered its appearance in the cases to defend the United States.

At the request of ERDA, the Department of Justice also entered its appearance in defense of the contractors in accordance with the litigation and claims provision of the ERDA contracts. Those provisions in ERDA management contracts allow the United States to conduct the defense of such claims against the contractors.

When the administrative claims were filed with ERDA, prior to the commencement of any of the lawsuits, ERDA reviewed these claims and in consultation with the Department of Justice determined that the claims had not established the liability of either the United

States or its contractors as alleged. It is clear from these actions that ERDA believes it and its contractors at Rocky Flats are not liable in these cases under the present state of the law. The plaintiffs obviously believe that they have been damaged and that ERDA and/or its contractors are liable. The plaintiffs have therefore filed lawsuits seeking a remedy from the court.

Under these circumstances the United States, acting through ERDA and the Department of Justice, has no choice but to engage upon an active and vigorous defense of these lawsuits in accordance with the applicable laws. It would be contrary to this defense and inappropriate for ERDA to comment on the lawsuits in a manner that exceeds the guidelines for release of information established by the local rules of the court and by the regulations of the Department of Justice. These rules and regulations are essentially identical, and the regulations may be found at 28 CFR part 50.2. The regulations limit us quite severely as to the nature and extent of comments that can be made concerning these cases. Specifically, we cannot speculate in a prejudicial manner as to the merits of the claims or defenses of any party to the lawsuits.

I am advised by the Office of the General Counsel at ERDA that these lawsuits present very complex questions of fact and law which will require the methodical treatment available in our courts of law for their final resolution. I realize that this may fall short of what you have in mind; however these are the circumstances as I currently understand them.

Mr. WIRTH. Could you tell us where we are in the development of the syn fuels legislation?

Dr. LIVERMAN. I cannot answer that specifically because I have not been following it. I thought that material had been sent to the Hill.

Mr. WIRTH. I was curious about the discussion last fall relating to the socioeconomic concerns.

Dr. LIVERMAN. I could talk a little about that.

Mr. WIRTH. We hope we will not have the same disaster that we had last fall with our legislation.

Dr. LIVERMAN. I wrote to the Governors. I asked for their comments. I received about 30 comments. We are waiting, at the request of the Western Governors Regional Energy Policy Board, to get their response. Their response is due shortly and then we will go over the comments of all of the people. We will look at the package that was sent out. We will probably come out with a Federal Register announcement. It will be broadcast for wide discussion as a basis for interaction.

That is about where it stands.

Mr. WIRTH. Are you working with Mr. McCormack and the Water Research Council on water issues?

Dr. LIVERMAN. Yes.

Mr. WIRTH. Has a formal relationship been established?

Dr. LIVERMAN. You have been provided a copy of the agreement. There was a meeting last Friday that I did not attend. Three members of my staff attended it with the Director of the Water Resources Council and Mr. McCormack. They let Mr. McCormack become acquainted in detail with what we are doing. The studies are proceeding. We are deliberating as to what additional studies may have to be done by others. There is a formal arrangement. We have a reasonably

formal one with Mr. McCormack's group. I have three people that spend all of their time on this interacting.

Mr. WIRTH. In testimony before Mr. Hechler's subcommittee, I think it was agreed that all the necessary studies had not been done. Perhaps this is the job of the Water Resources Council. They could take the studies and put them together to make some sense in terms of water availability, alternatives, and choices. They would get back to us as quickly as possible on what might be needed to be done. Perhaps we ought to do a case study on one or two States, rather than take on all of the Rocky Mountain region as we get into synthetic fuels.

Dr. LIVERMAN. When Mr. McCormack and I discussed this particular detail, your name entered the picture three or four times because of your interest in the area. Each man had a study with a different set of assumptions. What needs to be done is that we have to make sense out of the package. We have to know what the different assumptions and options are. Then you have a basis for a broad discussion as to what makes sense.

Mr. WIRTH. I appreciate your help. I will continue to move forward. Thank you very much.

Mr. BROWN. We have almost completed our questions.

Dr. LIVERMAN. Thank you.

Mr. BROWN. I would like to followup on some of the things Mr. Wirth had talked about in recognition of the increased level of scientific effort that will be needed in analyzing environmental impacts. As we step up our synthetic fuels program, what is the status of the scientific manpower situation? To what extent is ERDA, with other concerned agencies, seeking to insure a continuing supply of trained manpower in this area?

Dr. LIVERMAN. There are two areas of manpower needs. One has not been considered by some to be a need. It is the level of the pipe-fitter and the welder and the skilled laborer or technician. ERDA has about \$1 million in its budgets to worry about this. We have one of the few programs in Government that worries about it.

My own perception is that the country probably needs more of that kind of an effort; and probably it needs to be localized into various regions. For example in the Tennessee Valley region, TVA is putting in nuclear plants. Other people are putting in other kinds of plants. I can see how we would soak up or saturate all of the manpower that exists in that region. Do you import it or train new people? I think one has to look at that question. I don't think it has been adequately addressed. As to the other area, the scientific manpower for which the National Science Foundation has principal responsibility—well, let me say this. If you turn the sheet over, let us say around 1970 a decision was made by some one. I was not in Government at the time. I don't know who made the decision.

It was made to discontinue the program to monitor the training situation or manpower situation. I think what has happened to us in the intervening 5 years is that the data base to make meaningful decisions has sort of worn out. It probably needs to be put back in place. This year we have set aside a little money in our shop in order to look at both of these questions. The technician level and the scientific level.

I don't know whether it is an adequate amount or not. We had dis-

cussions at the National Science Foundation. We are always confronted with the problem that they have a far broader charge or charter. Their priority is on a manpower basis but it may not be the same as that of one agency or another in specialized areas. That is another reason to get the adequate data base.

We had a meeting the other day with 12 leading university academic vice presidents. We discussed this very topic with them. I make no judgment about what they said except that they said there is an inadequate manpower base to handle the energy industry in the country. As to how much data that concerns, I guess it rests upon their perception and experience. They uniformly said yes, there is a requirement, particularly in some of the engineering areas, and also in the basic underlying science area. We are not training enough or perhaps the right kind of people.

Mr. BROWN. It would be easy to come to the conclusion that because of the high level of unemployment, we have a surplus of workers in every category. This is not necessarily true in the highly specialized areas which will be required as we double or triple our efforts in energy or related environmental fields. That is the basis for the question.

Dr. LIVERMAN. I think it is terribly important that we get together the adequate data base on the manpower, its level of sophistication, and the levels that we need. Also, where is it located? This is so ERDA and others, when they go into different regions to try to establish new facilities and plants, can do this with our eyes open.

You can go into areas with much the same natural resource, where one has reasonably adequate manpower and the other has none. Then you obviously have a problem.

Mr. BROWN. I gather that you think there might be some usefulness in reestablishing the national register of scientific and technical manpower?

Dr. LIVERMAN. With some modification, yes. There were lots of arguments about it at the time. Some felt it had become bureaucratic and had not served a useful purpose. That is not a useful reason for disbanding it. You should fire the director and bring somebody else in. I think, yes, is the answer that is needed.

Mr. BROWN. The line of questioning that Mr. Goldwater was following, I believe, was intended to lead up to some inquiry about the amount of dollars in your 1977 budget that would be adequate to handle the required impact statements in the areas of solar and geothermal conservation. I was not present for all of this. Could you give us an indication as to whether you feel your office is in a position or is adequately funded to meet the requirements in this connection?

I am assuming you will move ahead rapidly in this area.

Dr. LIVERMAN. As you recognize, this is a difficult question to answer. I believe when our budget went through the agency and down to OMB, we had spelled out what we thought was a meaningful and effective budget, perhaps not totally aggressive, but one that would allow us to have the type of program needed within the time scales needed to conform to the technologies time lines to do with all what we have done with geothermal.

Now, as to priorities in the budgets as they came to the Congress, we did not get all that we had originally asked of OMB.

Mr. BROWN. Excuse me, did you provide the committee with figures that you submitted to the OMB? I do not have them in front of me.

Dr. LIVERMAN. Yes; you have the Holifield tables. We were asked last week when we appeared before Mr. Hechler to provide him with much more detailed answers as to what had been eliminated. It is being cleared through the OMB. I will try to answer any questions.

Mr. BROWN. We would like this. If those figures could be submitted, and if they would include the fossil elements, we would appreciate it.

Dr. LIVERMAN. Yes; this does include detail about the programs. As to what would be eliminated or not able to be funded.

Mr. BROWN. We merely want the opportunity to determine if the priorities of the Congress have been substantially violated by the activities of OMB. I have one further question.

Dr. LIVERMAN. Yes.

Mr. BROWN. I understand you have a major contract with the National Academy of Sciences with regard to analysis of the nuclear fuel cycle. Am I correct?

Dr. LIVERMAN. Yes; the agency does have a major contract.

Mr. BROWN. Could you outline very briefly the parameters of the contract? What have you asked them to do and what is the time frame?

Dr. LIVERMAN. I could comment briefly on that. Basically, as a result of correspondence that was initiated between Dr. Handler, the president of the Academy, and Senator Tunney last summer, the general gist of their exchange with Dr. Seamans was that they believed there should be a non-ERDA controlled study done of the whole nuclear fuel option.

As a result, a 2-year contract was awarded by ERDA's Planning and Analysis shop to the academies through the National Research Council in late 1975. Its scope is to study and review the issues associated with the alternative conventional and breeder reactors as sources of energy, including a study of the feasibility, costs, risks, and benefits of alternative nuclear power strategies.

In addition to that study, there was another one contracted with the National Academy of Sciences by the Division of Nuclear Fuel Cycle and Production to look at and evaluate the waste management practices at all ERDA facilities. There was a special subcommittee set up to study the Hanford facility which the National Resources Defense Council took exception with. As a result, a new contract has been renegotiated with the Academy which gives them more independence and a special subcommittee has been set up to investigate Hanford waste management practices in particular. This study, which is being funded in part by CEQ, is expected to last about 2 years.

Mr. BROWN. Thank you.

I would be interested to know if it would help me make a decision on the nuclear situation in California.

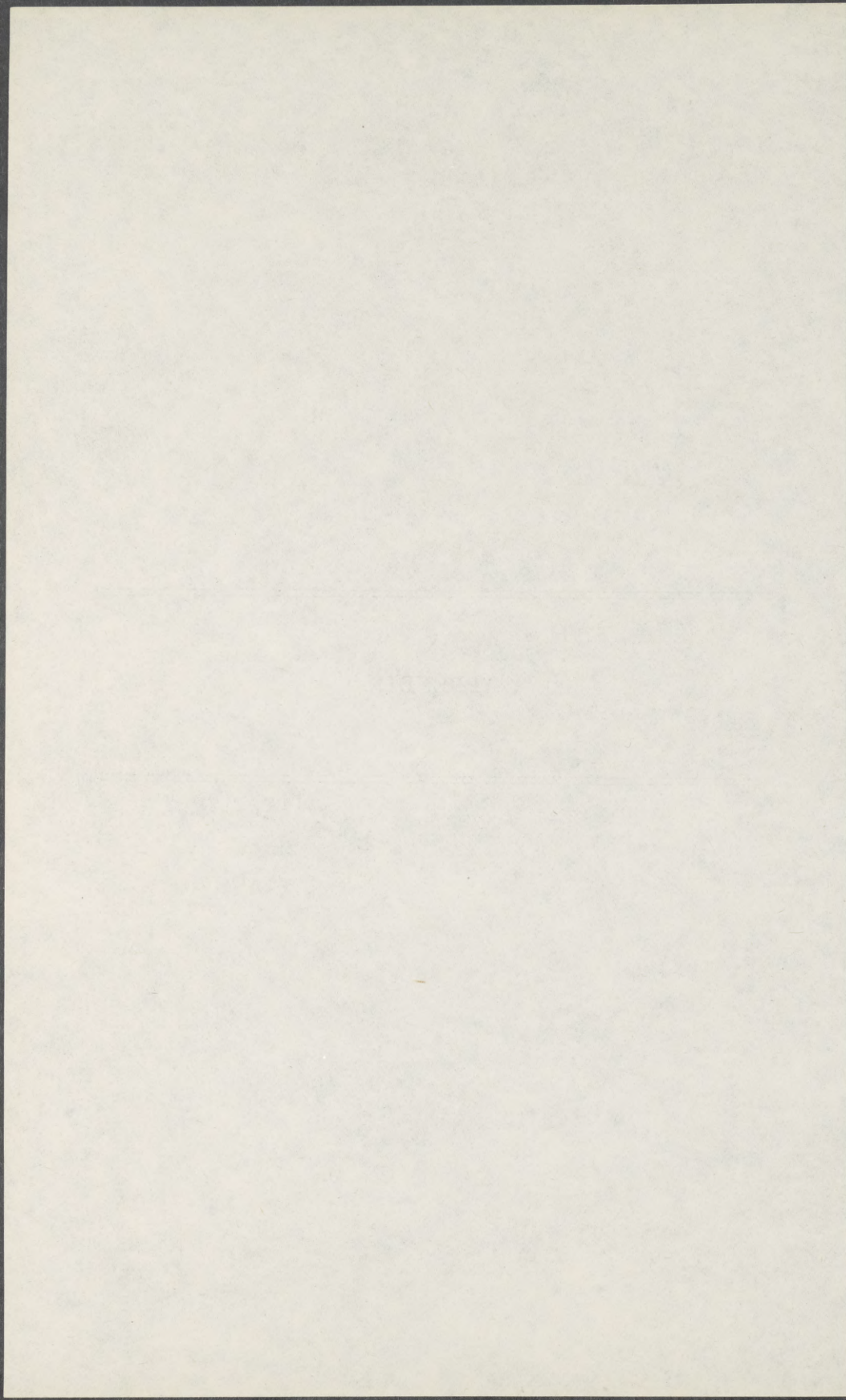
Dr. LIVERMAN. I did initiate, at the request of the Western Interstate Nuclear Board, a program with the Lawrence Livermore Laboratory and the Lawrence Berkley lab to provide technical expertise that existed to do a study of the impact of the moratorium in California or the Western States. I justified it on the basis that the Steering Committee was made up of the president of the Sierra Club and a pretty

broad based group. If I wanted to get an unbiased study, it would come out under such a sponsorship. That study is due to be finished in about the middle of April. That is about 6 weeks before the moratorium. It should help you.

Mr. BROWN. Thank you very much. If we have additional questions, I am sure you will assist us in your usual cooperative fashion. With that the subcommittee is adjourned until the call of the Chair.

[Whereupon, at 4:15 p.m., the subcommittee was adjourned, at the call of the Chair.]

APPENDIX



Environment and Conservation in Energy Research and Development

Assessing the Adequacy
of Federal Programs

A Report under Section 11 of the Nonnuclear Energy
Research and Development Act (P.L. 93-577)

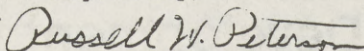
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EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

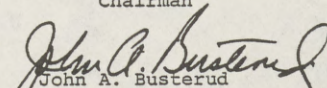
The President of the United States
The President of the Senate
The Speaker of the House
The Administrator of the Energy Research
and Development Administration

Sirs: The Council on Environmental Quality herewith
submits its report on Environment and Conservation in
Energy Research and Development, September 1976, in
accordance with Section 11 of the Nonnuclear Energy
Research and Development Act (42 U.S.C. 5910).

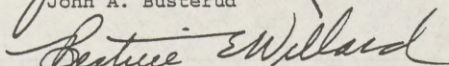
Respectfully,



Russell W. Peterson
Chairman



John A. Buserud



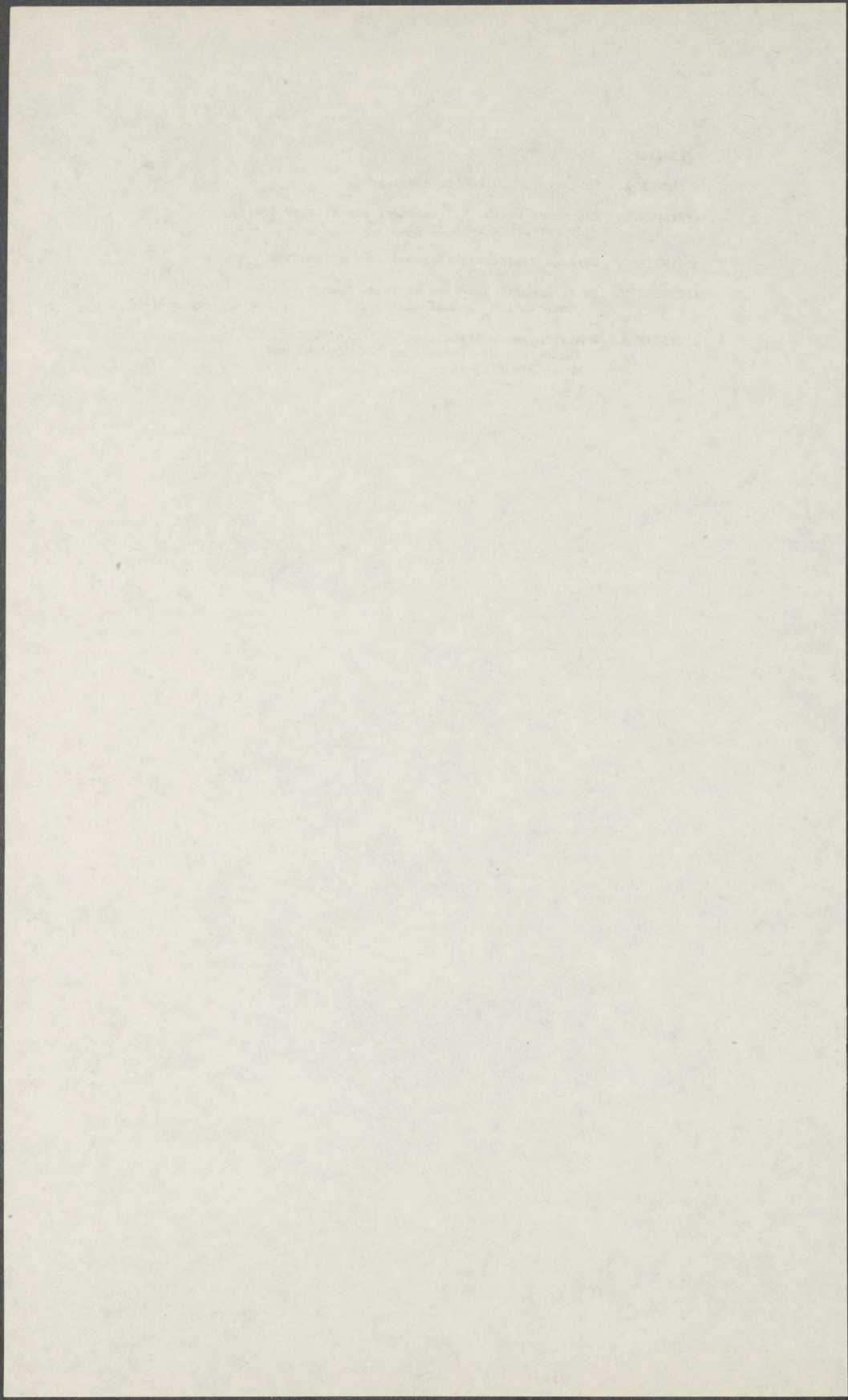
Beatrice E. Willard

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SUMMARY

When the federal government began a major restructuring of energy research, development, and demonstration programs in late 1974, a new Energy Research and Development Administration was established -- with a nonnuclear energy RD&D mandate to complement existing nuclear programs. In the implementing legislation, the Nonnuclear Energy Research and Development Act of 1974, the Congress paid particular attention to two areas that had been largely neglected in nonnuclear energy technology development: environmental protection and energy conservation.

The act gave the Council on Environmental Quality unique responsibilities with respect to federal nonnuclear energy RD&D programs: to conduct an ongoing analysis of the adequacy of attention to energy conservation methods and to environmental protection and to report to the President, the Congress, and the Administrator of ERDA on Council findings. This report is our first under that mandate; it covers activity through March 1976.

Our principal focus here is the Energy Research and Development Administration. We also examined related programs of the Environmental Protection Agency. ERDA's far-reaching goals and strategies, with implications for both the environment and energy conservation, are expressed in A National Plan for Energy Research and Development (ERDA-48) in 1975 and in the 1976 version (ERDA 76-1).

The many projects and people shifted to ERDA from other agencies brought with them programs and approaches that may well change under ERDA direction. The agency is still organizing its planning system and programs. To say that substantial improvements are necessary does not detract from ERDA's accomplishments. Moreover, some of the improvements which this report recommends are planned, and others are underway.

In approaching our review of the extent to which ERDA is taking conservation and environment into account, we first identified certain factors which we believe should characterize program planning and implementation. We then compared programs, interviewing officials in both ERDA and EPA, reviewing relevant documents, and undertaking special studies. The CEQ public hearings in September 1975 provided useful information and insights. Public hearings are planned on this report and the National Plan late this year.

In addition to overall assessment of planning and implementation, we analyzed two areas in depth in order to determine the extent to which environmental and conservation considerations are built into ERDA programs. This year's analyses focus on coal technology and end use conservation. It should be noted that federal conservation RD&D is but one aspect of the overall national energy conservation effort. The private sector can and must play a critical role in developing energy conservation alternatives in response to rapidly growing energy prices and associated influences upon demand for energy supplies. Conservation efforts can often be applied at state and local government levels as well. And even within the federal structure, conservation programs take many forms and involve many agencies.

Adequacy of Attention to Energy Conservation

The Council defines "adequacy of attention to energy conservation" in federal energy research, development, and demonstration as the capability to identify a range of possible energy conservation RD&D options, to create a factual basis for comparing them to other energy RD&D choices, and to develop programs that will ensure availability of the best options.

The National Plan

In April 1976, ERDA published its second National Plan. ERDA 76-1 singles out conservation technologies, ranking them along with several

different supply technologies as a highest national priority. This step represents a major shift in emphasis from ERDA-48, the first National Plan. It is based on further analysis of conservation opportunities, is responsive to public comment on the initial plan, and reflects ERDA's conclusions that only moderate progress is being made to date on development of supply technologies. To give effect to this priority, ERDA 76-1 establishes an immediate 5-year planning period during which energy conservation opportunities ready for commercialization will receive special attention. Further, the President's FY1977 budget increases ERDA's energy conservation RD&D resources by 64 percent.

The Council's assessment focuses on the revised National Plan and its underlying analyses and assumptions. We believe that ERDA 76-1 represents a substantial accomplishment for such a new agency:

- o The revised plan is a major improvement in addressing energy conservation and can serve as a benchmark from which to begin a systematic and complete approach to conservation RD&D.
- o The plan -- and its agenda for the future -- illustrate ERDA's commitment to a rational and analytical approach to energy RD&D. It is moving toward the systematic and explicit identification of energy problems and the development of technology to resolve them.
- o ERDA is actively seeking wide review and comment on its programs and appears responsive to comment.

These developments are most encouraging. However, our assessment raised a number of other issues which we believe were not adequately addressed in ERDA 76-1 but which are essential to building energy conservation into ERDA programs. These issues should be given high-priority attention and should be addressed specifically in the next revision of the National Plan in order to provide the basis for public review and debate which ERDA recognizes is important:

- o Is the near-term priority role established by ERDA for new energy conservation technologies -- primarily stressing demonstration and application of existing end use products and processes -- the appropriate one?

- o Is the energy conservation program for the midterm and the longterm adequate when measured against the potential benefits of conservation-intensive energy choices?
- o Are all potential conservation RD&D options fully considered, and are the energy conservation technology programs designed with adequate technical focus?

Identifying and Implementing Conservation RD&D Opportunities

To address these issues and to provide for building conservation into federal energy RD&D adequately will require the following:

- o A task-oriented, energy systems definition of energy choices, one which looks first at the nature of the tasks which energy is to perform and compares ways of doing the work, from the basic resource to end use
- o A process for deciding what RD&D should be done based upon ongoing comparisons of all potential RD&D options, whether they are supply or conservation oriented
- o Comparisons based on comprehensive assessment of the energy, economic, environmental, and social impacts of the options.

Without ongoing comparisons of RD&D opportunities based on a task-oriented, systems definition of choices and comprehensive assessment of impacts, ERDA's RD&D priorities may be misplaced.

Perhaps the most critical facet of building conservation into energy RD&D is development of the research programs. Individual program design must consider the energy needs that a technical option can fulfill, anticipate RD&D uncertainties, determine whether federal sponsorship is appropriate, and provide a likelihood of technical and commercial success. To do this, conservation program planning should:

- o Develop and use search and screening techniques for identification of high-payoff conservation RD&D opportunities
- o Establish a work planning procedure which focuses on individual high-payoff opportunities and ensures the availability of sufficient resources to resolve technical uncertainties.

Energy conservation offers substantial environmental benefits. Special care should be taken to develop environmental and other impact information on conservation technologies.

Principal Findings

Although the magnitude and technical direction of an adequate conservation program are not easy to determine, CEQ has serious concerns about the pace of improvement:

- o Although ERDA undertook systemwide analyses which considered the possible benefits of end use efficiency improvements in establishing priorities in the National Plan, it has not yet performed a task-oriented, systemwide evaluation of a full range of technological opportunities or made explicit side-by-side comparisons of RD&D options. Improvements in its planning and analysis systems, now being implemented, could provide the basis for the necessary comparisons.
- o Many of the basic agency policies and capabilities necessary to give conservation the same level of planning and management attention as supply enhancement, particularly for the more advanced technologies such as nuclear and coal, are still in a very rudimentary stage. Plans for improvement are vague.
- o Much of the social, economic, and environmental information necessary for comparison of all RD&D opportunities is not available. More important, sufficient research to provide this information is not built into the RD&D of the supply and conservation program offices.
- o The search for RD&D opportunities is ad hoc and is not uniformly applied over all time periods. It lacks the context of a long-term conservation strategy and does not employ innovative techniques to identify potential efficiency improvements. The method for screening RD&D options for inclusion in the program is more sophisticated but it lacks benefit, cost, and risk information.
- o ERDA's planning and budgeting are not effectively linked at all important levels. Without such linkage, broad agencywide decisions about what RD&D should be carried out cannot be translated with confidence into specific research projects.
- o Conservation planning resources are limited compared with those for the supply programs, which are supported by ERDA's extensive field laboratory structure.

Needed Improvements

Conservation RD&D is one of ERDA's high priority programs for the near term. Delay in building the capability to analyze, plan, and implement energy conservation RD&D options could jeopardize the benefits from ERDA's program in this period.

Equally important, there are potentially significant conservation RD&D opportunities over the mid- and long terms. These opportunities must be fully considered in the critical formative stages of ERDA planning. There is a momentum behind a number of supply programs, backed up by a relatively sophisticated planning capability. Failure to give adequate attention to mid- and long-term energy conservation programs will make it difficult to redress the balance later.

To ensure adequate attention to energy conservation, the following general improvements must be made within the next 2 years:

- o ERDA's analytical capability for planning, which is quite advanced, should fully incorporate conservation technology options. Information on economic, environmental, and social impacts must be considered.
- o Guidance to ensure the generation of necessary impact information and consideration of all the impacts of public concern should be formalized.
- o In the planning process specific conservation and supply RD&D opportunities should be compared across all planning periods; the comparisons should be used in establishing priorities and allocating resources.
- o The conservation RD&D programs must identify conservation RD&D opportunities over all planning periods, generate information to analyze the opportunities, and organize the research in order to realize the benefits of the best opportunities.
- o ERDA should carefully evaluate the extent to which the private sector can be expected to undertake the RD&D necessary to attain the potential national benefits of energy conservation.

ERDA appears to recognize these needs and is committed to a number of improvements. Included among these are a comprehensive planning system

which is task oriented, will add economic data to its analytical capabilities, and will employ market analysis to gauge the likelihood of commercial success of the technologies. These improvements could provide the basis for adequate consideration of conservation.

ERDA should prepare a detailed action agenda for making needed improvements. Until improved analytical planning methods are used to consider conservation programs equally with all other options in establishing RD&D priorities, ERDA's National Plan should make clear that priorities will be closely reevaluated annually.

Adequacy of Attention to Environment

The success of any technology ultimately depends upon its acceptance for economic, environmental and social reasons as well as for energy production. To ensure the production of environmentally acceptable technologies, environmental concerns should permeate all phases of energy research, development, and demonstration. They must be a major consideration for those charged with overall planning and administration of ERDA programs. Although ERDA has an Assistant Administrator for Environment and Safety, the environment should also be a major concern of the other program offices -- fossil fuels, solar, geothermal, and conservation.

The Environmental Protection Agency -- which must develop regulatory standards for new technologies -- shares the responsibility for ensuring the environmental acceptability of new technologies. EPA's environmental research and standard-setting programs, therefore must be closely coordinated with ERDA's technology development programs.

To build environment into the RD&D planning and decisionmaking process, comprehensive environmental information should be generated for all aspects of the energy technology systems in the RD&D program, and the information

should be fully applied in making decisions. This information should be used in selecting the most environmentally acceptable technologies from the entire range of possible RD&D options and within a particular set of options (for example, coal conversion technologies). To do this, all RD&D programs should demonstrate the following characteristics:

- o Environmental effects associated with developing energy technologies should be systematically assessed and environmental research addressed to priority problem areas. The technology and environmental research programs should provide the basis for setting environmental regulatory standards.
- o Technology RD&D should be scheduled to reflect availability of environmental research information; environmental research should be keyed to guiding hardware development; and facilities for development and demonstration should be designed to produce needed environmental data.
- o Decisionmaking for RD&D should incorporate procedures for ensuring that all necessary environmental information is available and that it is weighed in making commitments to technology development. Environmental assessments and environmental impact statements should be a major basis for these decisions.
- o A system of checks and balances should exist so that environmental information is developed when needed and that it is fully used as technologies proceed toward commercialization.

ERDA's National Plan recognizes that environmental protection and enhancement are concepts which "must be fully integrated into energy production and use." The National Plan makes a commitment to an environmental policy strategy which, while lacking detail, appears to include most of the characteristics set forth above. It also outlines the elements of an environmental planning system. These are important steps on ERDA's part toward adequately building environment into its technology programs.

This evaluation ends with the first quarter of 1976. As of that time, the environmental strategy had not been implemented nor had procedures been issued for the environmental planning system. Yet many technologies are

proceeding toward the later stages of development. In our view, implementation is too slow.

Principal Findings

Until recent years, little attention was given to identifying the environmental problems associated with developing nonnuclear energy technologies. This situation has been changing gradually. Since 1974 the federal environmental research program has devoted much more effort to the environmental problems and uncertainties of these technologies. But a well-defined and coordinated federal program does not yet exist. In particular:

- o There is not an effective, systematic approach to identifying priority environmental problems and to establishing a research program specifically related to developing technologies.
- o Coal technologies now being developed contain many hazardous substances in their process streams. The presence of these substances is poorly understood, and there is too little information on health and ecological effects. Possible effects from the end use of synthetic fuels is receiving only limited attention.
- o Individual coal technology RD&D programs lack a coherent approach to environmental concerns. Research to characterize pollutants from developing coal technologies and to identify potential health and environmental problems is not adequate.
- o ERDA and EPA have not developed procedures for setting environmental and occupational health standards for new coal technologies. Overall interagency cooperation and research coordination need major improvement.

These are difficult problems which require immediate, high-level attention. ERDA has initiated a major environmental planning effort, the Balanced Program Plan, which could remedy some of these shortcomings. In addition, proposed Environmental Development Plans for each RD&D program area could provide the needed technology-focused approach to environmental assessment and research.

Scheduling Environmental Research - We have a number of concerns with the relationship between the status of environmental research and the

schedules for development, demonstration, and commercialization of ERDA technologies:

- o Environmental research is not systematically linked to schedules for technology research, development, and demonstration, and no procedures have been instituted to ensure that environmental information is available when it is needed for key decisions. Procedures have been proposed to improve this situation.
- o The necessary environmental information for standard setting and other decisions on commercialization of coal-based synthetic fuels probably will not be available by the mid-1980's.
- o In the pivotal area of process characterization, research in the early and middle stages of development has been inadequate to identify potentially harmful substances associated with developing coal-based technologies. Recently initiated efforts could lead to a program to achieve this result. There is an equally critical timing problem with health effects research.
- o EPA's programs to establish environmental standards are tied to commercialization schedules only in the near term.

These inadequacies result in part from the fact that, at least for coal-based technologies, the federal environmental research effort is barely underway.

The proposed environmental planning efforts are designed to link environmental research with technology development. But these efforts are in the early stages, and with current schedules, significant effects on research timing are not likely to be felt before FY1980. Given the complexity of some of the research, and given a sequence -- process characterization to health effects to control technology -- which under the best of conditions will take a number of years, additional efforts should be made to ensure that sufficient information will be available for projected commercialization of developing coal-based technologies.

Considering Environment in Decisions - In examining the present approach to decisionmaking within ERDA, we find progress in some areas, but a number of significant problems still exist:

- o The National Plan was developed with only superficial consideration of the environmental effects of its alternative planning futures and did not discuss the environmental consequences of the technologies proposed for priority attention. The review process for the National Plan is good, but environmental information is lacking.
- o ERDA has committed itself to using environmental impact statements as major decision documents. This commitment is highly desirable, but is not yet backed by uniform guidelines and procedures directed explicitly at the problems of nonnuclear RD&D.
- o Some programs are progressing in developing impact statements. However, at the program level, commitments to demonstration of technologies have been made without sufficient consideration of environmental impacts.
- o Environmental considerations are not yet being adequately factored into individual project decisions. There has been no public or general federal agency review of program or project decisions through the NEPA process or by other means.
- o Procedures are evolving which could provide the basis for internal environmental checks on the planning and decisionmaking of the technology programs. They are not yet functioning, and decisions are being made with insufficient review.

We believe that well-defined procedures for preparation of environmental assessments and impact statements and for consideration of environmental information in decisions will result in more environmentally sound technologies.

Needed Improvements

ERDA should accelerate its efforts to implement the components of proposed environmental planning systems. It should also make clear how the various components -- Environmental Development Plans, the Balanced Program Plan, and environmental impact statements -- will fit together into a coherent program. In the coming year ERDA and EPA should emphasize coordination of their programs. The following areas should receive particular attention:

Technology-Environment Relationship

- o The technology RD&D offices under oversight of the Office of Environment and Safety should establish a complete environmental program for each technology encompassing assessment, coordination with environmental research and standard-setting agencies, and monitoring and control at RD&D facilities.
- o A central coordinating point should be designated to review the plans for technology development and environmental research to ascertain difficulties in scheduling and to make sure schedules are adjusted accordingly.
- o ERDA must carefully reevaluate its schedules for all nonnuclear energy technologies -- near-, mid-, and long-term -- to ensure availability of adequate environmental information for informed decisions on commercialization, environmental standards, control technologies, and other mitigating measures.
- o Providing environmental guidance to contractors in all technology development programs should receive immediate attention. It may be in the form of detailed regulations, manuals of practice which are incorporated into the contract, or contract specifications.

Process Characterization

- o All process characterization work should be systematically organized and coordinated to ensure the generation and sharing of necessary data.
- o Comprehensive programs for characterization of pollutants, (as well as definition of effects and development of control technology) should be in process for all pilot plants. They should not be downplayed until the demonstration stage on the grounds that only technical feasibility matters up until that point.

National Plan

- o The analysis underlying ERDA's National Plan should consider the environmental implications of program priorities in order to reflect the broad perspective that the Congress mandated.
- o Environmental issues should be specifically addressed in future revisions of the National Plan. ERDA should prepare a detailed environmental assessment of the National Plan and include it as part of its public review and comment.

NEPA Procedures

- o Implementation of proposed environmental impact statement procedures and environmental development plans should be greatly accelerated.
- o ERDA's procedures should carefully address the timing of environmental impact statements for all technology programs. Measures should be taken immediately to identify the program and project statements likely to be required, and preparation should begin as soon as possible to provide input into the decisions that will be made.
- o In the absence of comprehensive environmental information and detailed impact statements, ERDA should take great care not to make decisions which irrevocably commit to a course of action. There must be formal procedures for periodically reevaluating all significant commitments based on new information.

Health Effects Research

- o Additional attention should be given to rapid, inexpensive toxicological screening methods.
- o Efforts should be made to understand better the precise relationship between laboratory animal metabolism or cell cultures and human experience to allow quantitative estimates of health risks.
- o Better epidemiological studies and improved capability to isolate and identify past and present exposures to chemicals should be developed.

Research Coordination

- o A jointly constituted group should be established with responsibility for overall energy-environment research planning and establishment of program objectives and time tables. The entire federal energy-related environmental research program should be reexamined periodically to ensure coverage of the important issues associated with developing technologies.

Part One

BACKGROUND

Chapter 1

CEQ RESPONSIBILITIES

In 1974 the Congress and the executive branch made fundamental changes in the approach to and structure of federal energy research and development activities. The Arab oil embargo of the preceding winter dramatized a number of underlying energy problems which had previously failed to stir the general public. The impact of the embargo came as striking evidence of limited domestic supplies and of our growing dependence on imported oil and gas.

The embargo spurred efforts already being made by the government to come to grips with the realities of the nation's energy situation. New policy objectives were established: reduced dependence on foreign oil, accelerated development of domestic resources in an environmentally acceptable manner, and better use of these resources through energy conservation. Federally sponsored energy research, development, and demonstration is one means of helping to meet these national policy objectives.

The Energy Reorganization Act of 1974 created a new Energy Research and Development Administration to consolidate the energy R&D programs that were scattered among the agencies. The Nonnuclear Energy Research and Development Act of 1974 provided the framework and authority for a balanced nonnuclear energy R&D program to support a broad range of energy options. In this act, the Congress showed particular concern for two areas that had been largely neglected in nonnuclear energy technology development: environmental protection and energy conservation.

In Section 11 the Congress gave the Council on Environmental Quality new and unique responsibilities with respect to the nonnuclear energy RD&D programs:

- o To conduct an ongoing analysis of the adequacy of attention to energy conservation methods, to environmental protection, and to the environmental consequences of the application of energy technologies
- o To prepare reports to the President, the Congress, and the Administrator of ERDA on the Council's findings
- o To set forth in the President's annual environmental quality report the Council's findings on probable environmental consequences of trends in the development and application of energy technologies
- o To hold annual public hearings on the conduct of energy research and development.

The Council has taken a number of steps in response to this mandate.

The first series of public hearings was held in September 1975 in Washington, D.C., Los Angeles, and Detroit. A report on the hearings was published, and the testimony is summarized in Appendix A. The 1975 annual report included our first discussion of the environmental impacts of energy technology trends. Future annual reports will present Council analyses and findings.

Although the responsibilities set out in Section 11 are closely related, the Council views its primary charge as the continuing evaluation of attention to conservation and environmental protection, which expands and complements responsibilities mandated by the National Environmental Policy Act. The policy goals, the environmental impact statements, and other requirements of NEPA are important components of "adequate attention to environmental consequences" in the management of RD&D programs.

The Council looked closely at the legislative background of the Nonnuclear Act to determine the scope of our continuing analysis responsibilities. The Congress intended CEQ to monitor, assess, and make recommendations concerning the adequacy of attention which the agencies administering RD&D programs give to the energy conservation and environmental aspects of their programs.

The legislative background also suggested that the Council's analysis look beyond dollars and time allocated to examine how environment and conservation are considered in establishing RD&D priorities, in planning, and in program implementation. In short, the analysis should focus on how adequately environmental concerns and conservation are built into the energy research and development structure.

In analyzing the adequacy of attention to environmental and conservation aspects of energy technology, then, the Council should determine whether probable consequences are considered prior to initial commitment to a project or program and in choices among available program alternatives. The purpose of foreseeing adverse results is to avoid costly mistakes in the allocation of limited federal resources. This report covers federal RD&D activity through the first quarter of 1976.

Focus of Analysis

The principal focus of this report is the Energy Research and Development Administration. ERDA has primary responsibility for developing transitional and long-term technology and therefore manages the bulk of RD&D money and programs. It is charged with developing a national RD&D plan and updating it annually. Far-reaching goals and strategies, with implications for both the environment and energy conservation, were articulated in A National Plan for Energy Research, Development and Demonstration in 1975 (ERDA-48) and in the 1976 revision (ERDA 76-1). The decisions made in developing the National Plan are among those that the Congress intended CEQ to assess.

In view of congressional emphasis on the environmental consequences of energy technology, the Environmental Protection Agency was also a logical choice for assessment. Since its establishment in 1970, EPA has conducted extensive energy-related environmental research in support of its regulatory mission. Until the formation of ERDA, EPA was doing most of the government's nonnuclear environmental research.

Selecting appropriate energy conservation programs for assessment was more difficult. Federal conservation RD&D is but one aspect of the overall national energy conservation effort. The private sector can and must play a critical role in developing energy conservation alternatives in response to rapidly growing energy prices and associated influences upon demand for energy supplies.

Further, conservation programs span a number of federal agencies and include regulation of both private and public activities; grants and incentives; and research, development, and demonstration of ways to produce and use energy more efficiently. The Federal Energy Administration is directly involved in the regulatory and grant programs. For example, under the Energy Policy and Conservation Act, FEA establishes mandatory efficiency standards for automobiles and certain consumer products, sets up improvement targets for industrial energy use, and disperses conservation planning grants to the states. Other federal agencies undertake limited programs of conservation RD&D. The National Aeronautics and Space Administration researches improved aircraft efficiency techniques.

Because ERDA has principal energy RD&D responsibility and the broadest conservation RD&D mission, this assessment is directed at its attention to conservation planning and implementation. More efficient production and use of energy spans many of ERDA's program areas, for example RD&D of solar technologies. However, this year's assessment is

concerned primarily with end use conservation in buildings, transportation, and industry. Figure 1 shows the principal offices in both ERDA and EPA which are the subject of this assessment.

Assessing a New Organization

It should be noted that this first-year analysis was conducted while ERDA was forming and organizing its planning and programs and that many improvements were made during this period. Additional improvements now underway or being planned are discussed.

Many projects and people who were shifted from other agencies brought with them approaches to RD&D that may well change under ERDA direction. There are jurisdictional questions to be resolved. Further, as RD&D produces more information about various energy options, priorities may change.

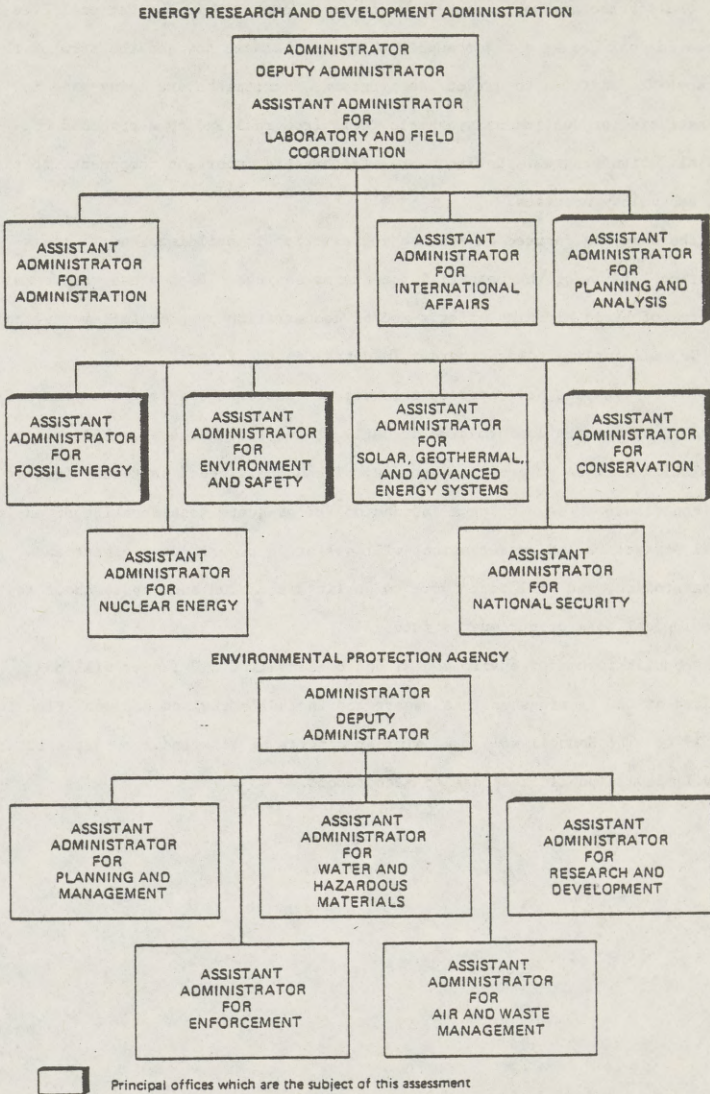
The Council believes that RD&D programs which give adequate attention to environment and conservation should display certain characteristics. These characteristics, which form the basis for our assessment, focus on agency processes: on efforts to gather facts through RD&D and to analyze them, and on ways to make choices and to take into account their probable outcomes. The characteristics are spelled out in Parts Two and Three.

This assessment is based on an intensive review of ERDA's program planning and implementation from publication of the first National Plan in 1975 to publication of the first revision, ERDA 76-1, in April 1976. We interviewed officials in ERDA and EPA, reviewed all relevant documents, and conducted special studies. Our public hearings in September 1975 provided useful information and insights.

Earlier studies by the Council, other government agencies, and private institutions provided a starting point for assessing environmental implications of energy systems: the interagency Energy Alternatives and a publication on the MERES data base for estimating environmental residuals are two such studies.

Figure 1

ERDA and EPA Organization Charts



In-Depth Analyses

In addition to the overall analysis of planning and implementation, in-depth analyses were conducted in two areas in order to determine the extent to which ERDA builds environmental and conservation considerations into its programs. The analyses focus on coal technology and end use conservation RD&D.

Coal technology was chosen in response to emphasis in the National Plan on increased coal use as a major supply objective between now and the turn of the century. In addition to direct use programs, commitments are being made to demonstrating production of synthetic fuels from coal and to a proposed commercialization program. Environmental factors are important components of these coal technology programs.

The analysis focused on end use conservation in buildings and in transportation because of the potential for energy savings. Both areas were examined in terms of broad planning efforts and of conservation program implementation.

We will analyze other programs in detail in the future.

The conclusions presented in this report recognize the fact that many of the R&D programs are in formative or early stages and that energy R&D policy formulation will be an evolving process. The Council hopes that our findings will contribute to developing a foundation for adequate consideration of environmental protection and conservation, will assist in program development and implementation, and will contribute to public discussion and debate about the technological base of our energy future.

A public forum for environmental and conservation R&D issues will be provided at CEQ hearings on this report and on ERDA's revised National Plan in late 1976. The Council will make similar reports on its findings in the future and will invite public response to each report.

Chapter II

PERSPECTIVE

History of Energy RD&D

In the past, neither conservation nor environmental considerations were significant in public or private energy R&D activities. The emphasis was on developing and improving energy supply technologies.

Until World War II, federal energy R&D programs focused on developing coal and petroleum resources, which were administered primarily by the Department of the Interior. The main agency was the Bureau of Mines (created in 1910), with its Division of Petroleum and Natural Gas (created in 1914).

After World War II, the emphasis shifted to development of nuclear power. The Atomic Energy Commission controlled the policy aspects of development, including the production, ownership, and use of fissionable materials. The 1954 Atomic Energy Act provided major impetus for private nuclear power development and vested the AEC with licensing and regulatory responsibility. Major research concentrated initially on demonstrating conventional fission nuclear power reactors for civilian use and later on demonstrating breeder reactors and nuclear fusion. The substantial environmental research program that emerged was directed primarily at reactor safety and possible adverse health effects of nuclear power.

Smaller nonnuclear energy R&D programs were scattered among government agencies, mostly within the Department of the Interior. In addition to the Bureau of Mines, the principal energy R&D agency was the Office of Coal Research, created by the Coal Research Act of 1960. The Bureau of Mines conducted inhouse research on gasification, magnetohydrodynamics, oil shale, petroleum, mining technology, and coal mine health and safety. The Office of Coal Research contracted for research on coal gasification, coal liquefaction, and magnethydrodynamics.

Unlike the nuclear research program, which was located in an agency with a single, clear focus, nonnuclear RD&D was an assortment of unrelated programs. Also unlike nuclear research, virtually no environmental consideration accompanied the research on fossil fuel technologies.

After 1970, small programs in solar heating and cooling systems and geothermal power were undertaken by the National Science Foundation, and R&D on alternate automotive power systems and research on energy-related health effects and control technology were conducted by the Environmental Protection Agency. EPA also undertook research on fluidized bed combustion and coal cleaning technologies.

Several major studies of federal energy R&D conducted between 1964 and 1974 suggested problems in program structure. Most recommended that while continuing to support nuclear development, the federal government should be more active in nonnuclear R&D, including oil and gas substitutes and development of renewable energy resources. The studies underscored the need for more emphasis on environmental control R&D and energy conservation R&D.

Growth of Environmental Interest

Interest in the environmental effects of energy production and use and in technology to prevent or lessen some of them had been growing since the earliest concern with pollution. During the 1950s and 1960s many of the environmental problems being identified were associated with energy: nuclear radiation, air pollution, oil spills, strip mined lands. Safety controls over nuclear powerplants were among the earliest manifestations of a federal responsibility for the environmental impacts of an energy system.

By 1970 the growing concern for environmental protection in general and for controlling energy-related effects in particular resulted in the passage of several laws which directly impact developing energy technologies (see Table 1). This legislation and regulations for implementation are affecting current development of nonnuclear energy, and they could profoundly affect the design of future

Table 1

Principal Federal Environmental Legislation
Affecting New Energy Technologies

Clean Air Act of 1970

- * EPA to establish primary ambient air quality standards (to protect the public health) and secondary air quality standards (to protect the public welfare) for pollutants which in the judgement of the Administrator have an adverse effect on human health and welfare. Presently regulate pollutants including sulfur oxide, nitrogen oxide, particulates, hydrocarbons, carbon monoxide, and photo chemical oxidants.
- * States are to prepare implementation plans to enforce and maintain ambient air quality standards.
- * Requires that State Implementation Plans include procedures to review prior to construction or modification the location of every "new source" to determine possible effects on the overall pollution control program.
- * The Administrator of EPA to establish standards of performance for all new major sources of air pollution, including levels of control achievable through the application of the best system of emission reduction the Administrator determines has been adequately demonstrated, taking into account the cost of achieving such reduction.
- * Permits states to adopt and enforce more stringent new source emission standards.
- * Establishes emission standards for light duty vehicles and requires the Administrator to set emissions standards for heavy duty vehicles.

Federal Water Pollution Control Act Amendments of 1972

- * EPA to set effluent standards for new sources reflecting greatest degree of effluent reduction achievable through the application of the best available demonstrated control technology; where practicable, a standard should permit no discharge of pollutants.
- * EPA to issue information on the processes procedures or operating methods which result in compliance with the new source standards.
- * EPA to set effluent standards for toxic pollutants at that level determined to provide an ample margin of safety.
- * Permits individual dischargers to show that the effluent limitation proposed for the thermal pollution of his discharge is more stringent than necessary to 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.
- * Establishes a permit system for enforcing effluent and water quality standards from point source discharges (except for discharges into publicly owned treatment works).

Table 1. Continued

- * Establishes a regulatory scheme to control the discharge of oil and hazardous substances.
- * Requires the preparation of an Environmental Impact Statement prior to the issuance of a new source permit.

Occupational Safety and Health Act of 1970

- * Requires the Secretary of Labor to promulgate occupational safety or health standards applicable to businesses affecting interstate commerce.
- * Provides an enforcement mechanism for such standards through workplace inspections.
- * Establishes the Occupational Safety and Health Review Commission to carry out the adjudicatory functions of the Act.

The National Environmental Policy Act of 1969

- * Requires that all policies, laws and regulations of the United States be interpreted to the fullest extent possible with the policies of that Act.
- * Include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment a detailed environmental impact statement.

energy systems. Systems must be designed in accordance with restrictions on air emissions, discharge standards for water quality, and occupational health and safety standards. Equally important, the new laws are not static; pollutants identified in the process of developing a technology may themselves be regulated. Energy development is also subject to review and assessment through the environmental impact statement procedures of the National Environmental Policy Act.

Emergence of Conservation Concerns

Although concern for environmental protection grew over the years, recognition of energy conservation as a national issue of paramount importance was relatively sudden.

There appeared little need to conserve in the 1950s and 1960s, when apparently abundant supplies of energy were available at low prices. Between 1950 and 1973 energy consumption increased at an average annual rate of 3.5 percent. During the last eight years of that period the rate rose to 4.3 percent. By then, however, some environmentalists, energy-intensive industries, energy experts, and government leaders were becoming alarmed. In his 1971 energy message, the President pointed up the need to use energy more wisely and more efficiently, both when produced and when consumed; in June 1973, he announced a major energy conservation program and a 5-year \$10 billion energy RD&D program. With imposition of the oil embargo that winter, the concern was urgent.

In Project Independence, a 1974 report prepared by the newly established Federal Energy Administration, energy conservation technologies were considered imperative in all the supply-demand combinations examined. Project Independence estimated that conservation technology improvements could reduce annual growth in demand to about 2 percent between 1972 and 1985. The CEQ Half-and-Half Plan also called for a serious long-term national program to conserve energy.

By 1974, then, environmental protection and energy conservation had emerged as energy policy goals to which both the executive and legislative branches had expressed commitment. The two were to be considered in the pursuit of the central policy goal of energy self-sufficiency.

New Federal Approach

Both the executive and legislative branches concluded that successful implementation of new energy policies required a more coordinated, expanded, and diversified federal R&D program. This concern led to the Energy Reorganization Act of 1974, which abolished the Atomic Energy Commission and created the Energy Research and Development Administration and the Nuclear Regulatory Commission. The new alignment separated regulation from development and centralized the major R&D. The principal energy R&D functions of the Department of the Interior and those of other agencies were transferred to ERDA, and authority for new programs in virtually all potential energy technologies was established by five new laws (see Table 2).

Policy Framework

Policy for federal nonnuclear energy R&D was set out in the Federal Nonnuclear Energy Act of 1974, in which the Congress stated: "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 by socially and environmentally acceptable means."

Throughout the act, the Congress emphasized the attention that R&D should give to the environmental impacts and energy savings possible from technology improvements. Committee reports also spelled out congressional intent that both aspects should be analyzed and considered in evaluating the comprehensive energy R&D program and its elements.

Principal Legislation and Reorganization Plans for Carrying Out
Nonnuclear Energy Research, Development and Demonstration

Federal Nonnuclear Energy Research and Development Act of 1974

- * ERDA to prepare a comprehensive plan for energy research, development and demonstration designed to achieve solutions to short, middle and long-term energy supply and associated environmental problems.
- * ERDA to develop a comprehensive nonnuclear energy research, development and demonstration program to implement the comprehensive plan.
- * Nonnuclear plan to include such elements as energy conservation, which must be given primary consideration, energy conversion, synthetic fuel development, in situ technologies, improved methods of extracting petroleum resources, environmental control systems for energy technologies, geothermal energy in accordance with the program authorized in the Geothermal Energy Research, Development and Demonstration Act of 1974, and solar energy in accordance with the programs authorized by the Solar Heating and Cooling Act of 1974, and the Solar Research, Development and Demonstration Act of 1974.
- * Environmental and social consequences of proposed programs to be analyzed and considered in evaluating a proposed program.
- * Authorizes federal assistance to or participation in demonstration projects for new energy technology.
- * Various forms of federal assistance authorized in carrying out the objectives of the Act including joint federal-industry corporations, contractual arrangements, federal purchases or guaranteed price of products of demonstration plants and federal loans to non-federal entities conducting demonstrations of new technologies and criteria to determine the appropriateness of federal involvement.
- * Provides for evaluations of water resource needs of nonnuclear energy technologies and demonstration projects.

Energy Reorganization Act of 1974

- * Establishes the Energy Research and Development Administration to plan, coordinate and direct energy research and development programs and to engage in and support environmental, biomedical, physical and safety research.
- * Abolishes the Atomic Energy Commission.
- * Transfers to ERDA certain energy R&D programs from other federal agencies, such as solar heating and cooling and geothermal development from the National Science Foundation, alternative automotive power systems R&D from the Environmental Protection Agency and fossil fuel research from the Department of the Interior.
- * Authorizes the Administrator to make arrangements including contracts, agreements and loans to conduct R&D activities with private or public institutions and persons including participation in joint projects.
- * Establishes the Energy Resources Council in the Executive Office of the President to coordinate federal energy policy.

Table 2 Continued

Reorganization Plan No. 3 of 1970

- * Establishes the Environmental Protection Agency.
- * Transfers to EPA authority over air and water pollution and environmental standards for the protection of the general environment from radioactive material.

Energy R&D Strategy

R&D planners face a difficult task in devising a strategy which balances all energy goals, including adequate supplies, environmental protection, and efficient use of resources. A possible approach was first set out in December 1973 in The Nation's Energy Future, prepared under the direction of Dixy Lee Ray, then Chairman of the Atomic Energy Commission. Project Independence provided further evaluation, and ERDA is now refining its energy strategy through the National Plans.

ERDA's overall strategy is built on the belief that heavy reliance on imported petroleum, petroleum products, and natural gas has serious national security implications and that import levels should be reduced. Because over 75 percent of the nation's energy consumption is based on petroleum and natural gas and because domestic supplies of these commodities are dwindling, the strategy is aimed at new energy sources.

Energy RD&D Funding

Although nuclear RD&D continues to dominate the federal energy RD&D budget, the nonnuclear portion has risen from 19 percent in 1970 to 47 percent in the proposed 1977 budget.

The current allocation of federal energy RD&D resources is shown in ERDA's proposed 1977 budget authority as sent to Congress (see Figure 2). ERDA's direct environmental RD&D funding of \$219 million is divided between control technology (\$16 million) and biomedical and environmental research (\$203 million). Energy conservation receives \$120 million. This includes end use conservation in buildings, industry, and transportation; electrical storage transmission and conversion; and use of solid waste as fuel.

³This figure represents program operating expenses net of \$75,000,000 in expected revenues.

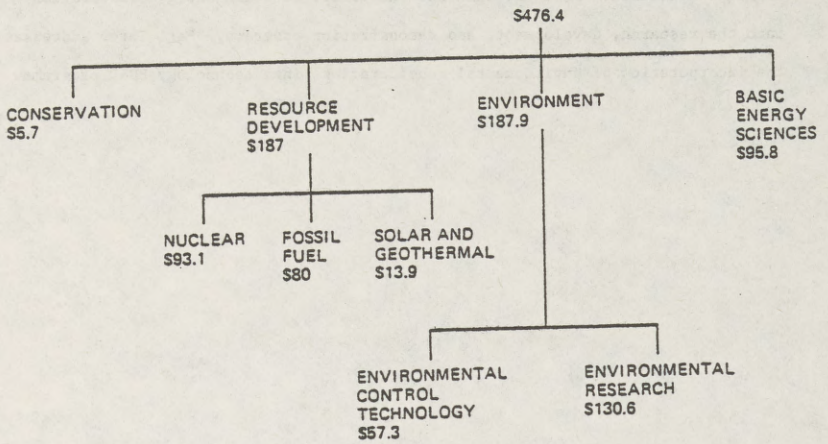
An additional \$476 million in budget authority was allocated in the 1976 budget to federal energy R&D programs in agencies other than ERDA (see Figure 3). Included were \$5.7 million for conservation RD&D and \$188 million for environmental research, reflecting a substantially increased federal emphasis in recent years.

Against this general background, the Council undertook to assess the adequacy of attention to conservation and environment in program planning and implementation. Part Two examines the effort to build energy conservation into the research, development, and demonstration programs. Part Three addresses the incorporation of environmental considerations into technology RD&D programs.

Figure 3

Non-ERDA Energy Related Budget Authority, FY1976

(\$ in millions)



Part Two
BUILDING ENERGY CONSERVATION
INTO RD&D

The Council defines "adequacy of attention to energy conservation" in federal energy research, development, and demonstration as the capability to identify a range of possible energy conservation RD&D options, to create a factual basis for comparing them to other energy RD&D choices, and to develop programs that will ensure availability of the best options. Part Two measures program planning and implementation at the Energy Research and Development Administration against this definition of adequacy.

Since publication of its first National Plan, ERDA-48, ERDA's attention to energy conservation has been under critical review by the Council and by others. Witnesses at the Council's 1975 public hearings questioned whether ERDA had given adequate priority initially to energy conservation, considering conservation's possible role and the small amount of federal resources allocated to conservation RD&D compared with the resources allocated to supply enhancement RD&D.

ERDA 76-1 singles out conservation technologies, ranking them along with several different supply technologies as a highest national priority. This step represents a major shift in emphasis from ERDA-48. It is based on further analysis of conservation opportunities, is responsive to public comments on the initial plan, and reflects ERDA's conclusion that only moderate progress is being made to date on development of supply technologies. To give effect to this priority, ERDA 76-1 establishes an immediate 5-year planning period during which energy conservation opportunities ready for commercialization will receive special attention. Further, the President's FY1977 budget increases ERDA's energy conservation RD&D resources by 64 percent.

This assessment focuses on the revised National Plan and its underlying analyses and assumptions. We believe that ERDA 76-1 is a substantial accomplishment for such a new agency:

- o The revised plan is a major improvement in addressing energy conservation and can serve as a benchmark from which to begin a systematic and complete approach to conservation RD&D.
- o The plan -- and its agenda for the future -- illustrates ERDA's commitment to a rational and analytical approach to energy RD&D. It is moving toward the systematic and explicit identification of energy problems and the development of technology to resolve them.
- o ERDA has undertaken a substantial effort -- some of which began prior to ERDA 76-1 but was not complete by the first quarter of 1976 -- to improve the plan and to make the ERDA program more effective.
- o ERDA is actively seeking review and comment on its programs and appears responsive to comments.

These developments are most encouraging. Yet in responding to our mandate, the Council must measure adequacy against plans and programs now in place and operating. We recognize ERDA's progress and the many positive steps already underway, but we have identified several problems:

- o Many critical issues affecting the role of conservation in the overall energy RD&D program have not yet been resolved (see Chapter III). In particular, the planning, development, and commercialization time frames and levels of effort for conservation RD&D programs have not been thoroughly addressed.
- o The current National Plan is not yet built on analytical comparisons of all promising RD&D technology opportunities based on their technical, economic, and environmental characteristics.
- o Granted that conservation is a new program in a new agency, there remain serious questions about the rate of progress in developing the analytical ability to compare conservation technologies with the more advanced energy supply technologies.

The magnitude and technical direction of an adequate conservation program are not easy to determine. We also realize that simply "throwing" money at conservation would be wasteful. Nevertheless, we are seriously concerned about the pace of improvement for several reasons:

- o Many of the basic agency policies and capabilities necessary to give conservation the same level of planning and management attention as supply enhancement, particularly for the more advanced technologies such as nuclear and coal, are still in a very rudimentary stage. Plans for improvement are vague.
- o The conservation programs are not generating essential technical, economic, and environmental information to permit analysis of conservation opportunities and planning based on conservation-supply comparisons; sufficient work to produce the information in the future is not being undertaken by the programs.
- o Conservation planning resources are limited, compared with those for the supply programs which are supported by ERDA's extensive field laboratory structure.

Conservation RD&D is one of ERDA's high priority programs for the next 10 years. Delay in building the capability to analyze, plan, and implement energy conservation RD&D options could jeopardize the benefits from ERDA's programs in this period. In short, much of the near term could pass before ERDA fully integrates a conservation capability into its overall planning and management structure.

Equally important, there are potentially significant conservation RD&D opportunities over the mid- and long-terms. These opportunities must be fully considered in the critical formative stages of ERDA planning. Momentum tends to build as commitments are made to specific sets of technologies and as multiyear claims are made on future funds. Already there is a momentum behind a number of mid- and long-term supply programs, such as those to produce gas and liquid fuels from coal and advanced nuclear systems, backed up by a relatively sophisticated planning capability. Failure to give adequate

attention to mid- and long-term energy conservation programs will make it difficult to redress the balance later.

To ensure adequate attention to energy conservation, the following general improvements must be made within the next 2 years:

- o ERDA's analytical capability for planning, which is quite advanced, should fully incorporate conservation technology options. Information on economic, environmental, and social impacts must be considered.
- o Guidance to ensure the generation of necessary impact information and consideration of all the impacts of public concern should be formalized.
- o In the planning process specific conservation and supply RD&D opportunities should be compared across all planning periods; the comparisons should be used in establishing priorities and allocating resources.
- o The conservation RD&D programs must identify conservation RD&D opportunities over all planning periods, generate information to analyze the opportunities, and organize the research in order to realize the benefits of the best opportunities.
- o ERDA should carefully evaluate the extent to which the private sector can be expected to undertake the RD&D necessary to attain the potential national benefits of energy conservation.

Chapter III

MAJOR ENERGY CONSERVATION ISSUES

This chapter evaluates the National Plan in terms of adequacy of attention to energy conservation. Several issues essential to building conservation into ERDA's programs were not adequately addressed in ERDA 76-1. These issues should be given high priority attention and should be addressed specifically in the next revision of the National Plan, in order to provide the basis for public review and debate which ERDA recognizes is important:

- o Is the near-term priority role established by ERDA for new energy conservation technologies -- primarily stressing demonstration and application of existing end use products and processes -- the appropriate one?
- o Is the energy conservation program for the mid term and the long term adequate when measured against the potential benefits of conservation-intensive energy choices?
- o Are all potential conservation RD&D options fully considered, and are the energy conservation technology programs designed with adequate technical focus?

The Near-Term Role for Energy Conservation RD&D

There are two additional adequacy of attention issues with respect to the substance of ERDA's near-term strategy:

- o Will ERDA's energy conservation strategy make technically and commercially adequate conservation technologies available in the near term?
- o Is current energy conservation RD&D adequate to the high priority, near-term goal that ERDA set?

A major purpose of ERDA's revised plan is to broaden the nation's range of available energy options. Table 3 lists the plan's ranking of "highest priority" demand and supply technologies. We agree that energy conservation is critical in the near term and support the additional resource commitment, but we are concerned with the lack of specificity as to ERDA's role during this

Table 3: Proposed Priorities for RD&D Technologies

<u>Highest Priority Demand</u>	
Near-Term Conservation (Efficiency) Technologies	. Conservation in Buildings and Consumer Products . Industrial Energy Efficiency . Transportation Efficiency . Waste Materials to Energy
<u>Highest Priority Supply</u>	
Near-Term Major Energy Systems	. Coal-Direct Utilization in Utility/Industry . Nuclear-Converter Reactors . Oil and Gas Enhanced Recovery
New Sources of Liquids and Gases for the Mid-Term	. Gaseous and Liquid Fuels from Coal
"Inexhaustible" Sources for the Long Term	. Oil Shale . Breeder Reactors . Fusion . Solar Electric
*Source: <u>ERDA 76-1</u>	

period. Because near-term conservation is high priority, commercial or nearly commercial technology will form the basis for the RD&D program for the next 5 years. The plan describes the major near-term opportunities in the three energy end-use sectors as:

- o Industry conservation: "(a) host of more efficient technologies ... is known."
- o Buildings conservation: "(a) number of specific technologies exist ... that need to be integrated and may require innovative marketing by industry to motivate consumers to accept and install them."
- o Transportation energy conservation: "(the) transportation sector ... can reduce its petroleum consumption by using well-proven technologies and by implementing well-studied operational changes."

ERDA 76-1 identifies the main RD&D obstacle with respect to this host of available technologies as overcoming "problems of economic uncertainties and normal resistance to the acceptance of new 'products.'" A five-part energy conservation strategy is based on "a national policy conducive to the adoption of energy-efficient technologies; a five-year planning horizon; accelerated identification of promising technologies and dissemination of information about their application; integration of market and institutional barriers into the plans for developing the most attractive conservation technologies and for facilitating their implementation; and demonstration programs to work out the implementation details."

Early application of available conservation technologies makes sense as a good consumer investment and is in the public interest. But much of ERDA's strategy is commitment to existing technologies, essentially "off the shelf." No significant resources are devoted to upgrading their efficiency. For example, although heat pumps are being used in several building demonstration projects, there is only a limited RD&D program to improve heat pump performance or to develop advanced heat pumps. In contrast,

prior to commercialization, ERDA plans to upgrade economically and technically submarginal supply technologies such as coal liquefaction, coal gasification, and tertiary oil recovery. Conservation technologies do not receive the same attention.

Two additional questions relate to ERDA's concept of energy conservation:

- o Is the near term the appropriate high-priority time frame for federal energy conservation RD&D?
- o Is there more new mid-term and long-term conservation RD&D that should also have high priority considering potential national benefits?

One of the chief reasons for ERDA's assignment of high near-term priority to conservation is that few, if any, major new supply technologies can provide significant energy by 1985. However, while concentrating on energy conservation in the near term, ERDA may be neglecting important and needed conservation opportunities in the mid- and long-term planning periods. Conservation then could become an important source of energy if new supply technologies lag in development because of a combination of technical and institutional problems (past major transitions to new fuel supplies have taken 50 years or more; ERDA is hoping for significant results from its supply programs in 10-20 years) or because of potentially serious environmental problems (see Part Three). The longer new supply technologies lag, the more energy conservation must do to reduce the gross energy required to meet the same human needs.

Should new supply technologies fail or fall short of current expectations, the cost of energy could rise even more than expected. Higher-priced energy automatically generates a market for improved energy conservation technology. However, failure to conduct basic RD&D now to provide energy conservation opportunities for the mid- and long-terms could mean that neither conservation nor supply technologies will be available when and if they are needed.

Conservation Program Size

Four underlying issues should be addressed by ERDA:

- o Are the short-term factors which translate conservation's high RD&D priority into ERDA's smallest energy RD&D program (its newness and relatively early state of planning) also applicable in the mid term and long term?
- o In developing its programs, is ERDA considering conservation benefits and the likelihood that private RD&D will produce the technology needed to realize these benefits?
- o Should a substantial federal conservation RD&D program exist as insurance against the risk of losing the large benefits of conservation?

It was noted earlier that ERDA's proposed energy conservation budget increased 64 percent between FY1976 and FY1977. However, energy conservation received only 6 percent of the agency's total increase.

Energy conservation's share of ERDA's total program, not just the annual increase, is small relative to supply -- 4 percent of the total (see Figure 2 for a comparison). Conservation ranks next to the smallest major RD&D program.

The primary reasons for this situation are obvious: conservation is a new program that started small and is growing fast; it is still in the early and relatively low cost stages of planning and development whereas some supply technologies are well into the most costly demonstration stage. However, we believe that these are short-term conditions. They should be assessed to assure that conservation is receiving a share of RD&D resources commensurate with the potential benefits and the appropriate federal role. In the future ERDA should make explicit comparisons of the allocation of resources versus the potential benefits of conservation relative to supply RD&D.

ERDA 76-1 observes that a barrel of oil saved can reduce imports at less cost than producing one through development of a new supply technology; that energy conservation generally has a more beneficial effect on the environment;

and that capital requirements to increase energy use efficiency are generally lower than to produce an equivalent amount of energy from new sources (most new supply technologies are highly capital intensive). Further, the benefits continue over time because the use of conservation as a "source" of energy can relieve pressure for new supply technologies.

As a measure of benefits, ERDA 76-1 estimates energy impact goals for each energy technology in the year 2000. On the basis of this benefit measure, the proportions of RD&D effort directed at energy conservation and at the supply technologies with which it competes in the near- and mid-terms vary widely. Supply enhancement contributes about 66 percent of the total year-2000 goal and receives about 90 percent of the ERDA RD&D funds in FY1977. Conservation technologies contribute 22 percent and receive 4 percent.

ERDA 76-1 states that national priorities for energy RD&D do not necessarily line up with allocation of funds. Specifically, primary responsibility for the development of conservation technologies rests with the private sector because in general they can be implemented with less government involvement than can supply technologies. This may be the case, particularly for near-term conservation opportunities.

Major allocation of resources among RD&D options should not be made subjectively. When the benefit-cost ratio of a conservation technology appears to be high, care must be taken to compare that opportunity on an equal footing with all competing options. The risk that, for institutional or other reasons, the private sector will not develop energy conservation technologies, or will not develop them soon enough should be carefully considered in allocating resources. If the risk appears to be too great in terms of lost or diminished benefits to justify near-exclusive reliance on private industry, the government should develop these technologies.

To illustrate the benefits side of the equation further, the Council estimated consumer savings from technical improvements in major portions of the transportation and buildings end-use sectors (see Table 4). The proposed funding levels in FY1977 for these R&D programs amounted to \$12.8 million, \$1.2 million, and less than \$2.7 million respectively.

These rough estimates, like ERDA's, indicate large potential benefits from improved end use devices. Over time rather than just at the year 2000, the gap between potential benefits and planned federal RD&D grows even wider. Although this is a rough comparison, which does not consider the full social costs of implementation, the ratio of potential benefits compared to current expenditures appears so cost effective as to justify significant investment.

These estimates compare long-term national benefits with the one-year ERDA funds directed at conservation. However, this is not the only kind of comparison that should be used to assess the rationality of ERDA's allocation of funds among energy conservation strategies or between conservation RD&D and supply RD&D. A more precise analysis would measure the incremental increase in likely national savings expected from allocating additional ERDA funds to a research area. For example, while the expected total energy savings from a conservation strategy may be high, the impact of additional ERDA research on this savings may prove small, either because the full potential is known or because the required research is being carried out by other public or private institutions. Conversely, another strategy may offer less potential for total energy savings, but the savings to be realized could be highly dependent on ERDA research.

ERDA has not yet established research planning and analysis which produce the kinds of information required to make these judgments. The CEQ review,

Table 4: Energy Conservation Benefits and RD&D Funding

	Incremental * Benefits (\$millions)	FY1977 ERDA Program (\$millions)
• AUTO EFFICIENCY - Redesign of non-engine components - Engine re-design . Stratified charge, <u>or</u> . Diesel, <u>or</u> . Stirling, <u>or</u> . Brayton	\$59,000 mm 21,000 23,000 28,000 29,000	{ 12.8
• BUILDING EFFICIENCY - Improved insulation, Residential Heating Standards - Reliable electric heat pumps - Reliable thermally activated heat pumps	13,000 11,000 2,000	{ 1.2 < 2.7

* After allowance for the time-value of money; constant 1975 dollars.
The basis for these results is detailed in Appendix B.

therefore, though recognizing the weakness in the analysis, has had to depend upon comparisons between total savings and research allocations. However, in a general way, they do illustrate the apparent cost-effectiveness of investments in energy conservation.

Conservation RD&D Opportunities

With regard to conservation opportunities, there are three issues which require attention:

- o What alternative approaches could be used to identify and compare conservation RD&D opportunities?
- o Are ERDA's estimated energy savings backed up by research work focused with sufficient depth on high payoff options?
- o What factors explain the large variations in levels and concentration of effort among the energy conservation programs?

As noted, ERDA 76-1 states that conservation technologies "provide a potential cost-effective alternative" to development of more supply technologies. Realizing this benefit will require the identification of potential conservation as well as supply opportunities. In order to allocate funds objectively, ERDA should rank all potential opportunities according to cost-effectiveness without attention to whether they are conservation or supply oriented. Of course, other factors, such as the likelihood of commercialization of a technology without government assistance, must also be considered.

At this early stage in its development, ERDA has no such resource allocation system. Yet without making explicit comparisons, ERDA believes that its conservation efforts will go far toward making a substantial difference in our energy future. Planned accomplishments are related to a "no conservation" forecast of future energy use. This kind of yardstick alone cannot identify what energy conservation RD&D should be carried out in relation to supply RD&D.

One alternative approach would measure conservation objectives against the maximum energy savings physically achievable. Theoretical physical principles provide a steady reference for measuring present against potential technology efficiencies. The Second Law of Thermodynamics states the maximum fraction of a given quantity of heat energy which can be converted into useful work (the fraction is always less than 1). Energy is not destroyed in producing work; it changes from a high-quality form (one with a large fraction of its heat content available to perform work) to a lower-quality form. This quality feature stems in part from the temperature of the energy source rather than simply from the quantity of heat energy that it contains. The change in quality or work-producing potential -- rather than in quantity of energy -- is what is used up irretrievably in converting energy into work. Under a Second Law approach, the source of energy and the work it is used for should be matched: high-temperature energy sources should be reserved for tasks which only high temperatures can do, and successively lower temperatures should be devoted to low-temperature tasks. Second Law efficiency measures the extent to which a perfect match is achieved in practice.

Rough thermodynamic calculations indicate that the ERDA-48 energy conservation outlook -- a 25 percent improvement by today's energy efficiency standards -- captures by the year 2000 only about 20 percent of the theoretical maximum efficiency improvement (see Table 5).

We emphasize that application of Second Law principles only indicates a theoretical maximum and therefore serves only to estimate the maximum size of the efficiency gap as a lead to where real world energy conservation RD&D opportunities may exist. By themselves these calculations could not translate directly into an RD&D program. First, the full measure of theoretical energy savings cannot be realized. As thermodynamic efficiency is increased more and

Table 5: Idealized Maximum and Planned Energy Savings

ENERGY CONSERVATION TARGET	ERDA	2nd-Law Maximum	Percent
	Year-2000 Goal (Quads)		
Industrial Process Heat	2.0	13.9	14
Automobile Transportation	3.7	11.6	32
Bus, Truck and Rail Transportation	1.8	8.0	22
Building Space Heating Systems	1.6	7.4	22
Air Transportation	1.3	7.3	18
Industrial Electric Drive	1.0	4.6	22
Building Air Conditioning Systems	0.7	4.6	15
Buildings Electric Devices	1.1	2.9	38
Buildings Thermal Improvement	0.4	2.8	14
Ship Transportation	-	1.5	0
Iron and Steel Production	0.2	0.8	25
Primary Aluminum Production	0.04	0.3	13
Electric Mass Transportation	-	0.2	0
Total	13.84	65.9	21%
Source: Based on ERDA-48 Vol. 2 and Efficient Use of Energy: A Physical Perspective, American Physical Society			

more, other physical factors begin to act as a limit. Most important, the Second Law of Thermodynamics does not consider economics. For both reasons, it can only suggest an upper limit on the extent of energy conservation possibilities that should be explicitly explored.

Ideally, individual energy conservation RD&D pursued by ERDA's Office of Conservation Programs should focus on opportunities with the greatest energy savings potential. RD&D should be concentrated in these high payoff areas to ensure their technical and commercial success. Of course, the lack of correlation between savings and effort could stem from several causes: differing energy savings opportunities, the state of advancement of technology, or the existence of nonfederal research efforts. In addition, as pointed out earlier, benefits in terms of additional national savings from allocating RD&D funds to a particular research effort must be considered. But large deviations between focus of effort and potential energy savings are a signal that ERDA's system for assigning priorities within the energy conservation RD&D program may be inadequate.

The Council reviewed 110 project areas within 18 budget categories of the OCP FY1977 program and budget and compared them for consistency in focus of effort versus potential savings. The OCP budget categories expected to contribute the largest share of 1985 energy savings might be expected to receive the largest share of the total OCP budget. Within each high payoff budget category, the average level of funds available for each project area might be expected to match the high average energy savings expected from each (see Table 6).

Our major observation is that the two areas of largest expected savings -- industry conservation and new technologies for buildings ("other buildings") -- are being funded below their expected contribution to energy savings. They

Table 6: ERDA's Office of Conservation Programs FY1977 and Projected Energy Savings 1985

	FY77 B/A & Obs. ¹	1985 Savings ²	Budget	PERCENT ³	Savings
<u>PROJECT SUBCATEGORIES</u>					
ELECTRIC ENERGY SYSTEMS & ENERGY STORAGE					
1. Electric Energy Systems					
Systems Management & Structuring	6,810	710	6.5	11.1	
Electric Power Transmission	12,890	60	12.3	0.9	
2. Energy Storage	20,840	450	19.8	7.0	
END USE CONSERVATION & TECHNOLOGIES TO IMPROVE EFFICIENT					
1. Industry Conservation					
Unit Operations & Equipment Efficiency	8,650	2,250	8.2	35.0	
Process Analysis & Modification					
Alternative Fuels, Materials & Processes					
Agriculture & Food Processes					
2. Buildings Conservation					
Commercial Buildings	3,850	200	3.7	3.1	
Residential Buildings	3,075	280	2.9	4.4	
Community Systems	6,850	600	6.5	9.3	
Urban Wastes	5,950	360	5.7	5.6	
Appliances					
Technology					
3. Transportation Energy Conservation					
Heat Engine Highway Systems	14,790	510	14.1	7.9	
Electric & Hybrid Systems	4,550	80	4.3	1.2	
Implementation & Equipment	1,800	340	1.7	5.3	
Nonhighway Transport Systems					
4. Improved Conversion Efficiency	15,000	580	14.3	9.0	
PROJECT SUBTOTAL	105,055	6,420	100	100	
<u>SUPPORT SUBCATEGORIES</u>	<u>7,945</u>				
TOTAL OPERATING EXPENSES	113,000				

1/ Operating Expenses, Dollars in Thousands

2/ Thousands of Barrels of Oil Per Day -- Equivalent

3/ May not add to 100 percent due to rounding

Source: U.S. Energy Research and Development Administration, FY1977 Budget Estimates

account for about 50 percent of the 1985 savings and about 20 percent of the effort in FY1977. In contrast, energy storage and heat engine highway systems account for about 30 percent of the budget and only about 10 percent of the savings.

Resolving The Issues

Addressing these issues is critical to ERDA's energy RD&D mandate and to meeting the responsibilities that its mandate implies. All of them are inherently complex, and the answers will make an enduring imprint on our future energy choices. Their resolution will depend on the methodology ERDA employs to plan and implement energy RD&D.

ERDA 76-1 recognizes the distance remaining to a fully adequate national energy RD&D plan and research program. To further ERDA plans and programs, a new framework for planning and implementing energy RD&D -- a Program Planning, Budgeting and Review System -- will be set up. The concepts it reflects are ambitious and are theoretically advanced. Because only the rudiments are there, we will discuss the methods that ERDA used to formulate its energy RD&D program and the efforts that are underway to enhance ERDA's capacity to address the issues set forth above.

CHAPTER IV

DECIDING WHAT RD&D TO DO

The Council believes that adequate provision for building conservation into ERDA's overall planning for energy RD&D requires:

- o A task-oriented, energy systems definition of energy choices, one which looks first at the nature of the tasks which energy is to perform and compares ways of doing the work, from the basic resource to end use
- o A process for deciding what RD&D should be done based upon ongoing comparisons of all potential RD&D options, whether they are supply or conservation-oriented
- o Comparisons based on comprehensive assessment of the energy, economics, environmental, and social impacts of the options.

Ultimately, the judgment of decisionmakers will determine the composition of RD&D programs. We believe, however, that consideration of these three elements is basic to informed decisions. This chapter expands on the elements, outlines and evaluates the extent to which ERDA used this approach in developing ERDA 76-1, and discusses improvement efforts which ERDA is undertaking. A chapter appendix illustrates an analytical approach which we believe includes the principal elements for consideration of energy conservation and highlights areas where further analysis is needed.

The Task-Oriented Approach

The task-oriented approach identifies energy RD&D opportunities by looking first at the nature of the tasks which energy can perform and at alternative ways to do them using different amounts of energy. Starting with end use, it then generates and compares alternative configurations of end-use devices and supporting distribution systems, transport modes, conversion processes, and energy resources to serve them.

Traditionally, those planning for energy policy decisions looked first at energy resources and alternative conversion processes and methods. Often this

traditional systems approach ignored the final end use step as well as the nature of the tasks which create energy needs. As a result, new and different end use methods and devices were often overlooked.

The difference may be clarified by considering home heating. The traditional analysis begins with mining the coal and then compares ways of converting, transporting, and distributing it to homes in raw form or as a gaseous or liquid fuel or as electricity. The task-oriented approach begins with maintaining a comfortable indoor residential temperature in the most efficient manner.

The task-oriented approach is a better way of analyzing energy choices because, by broadening the view of energy end use, it opens up new possibilities for energy conservation early on. As a first step in the search for energy RD&D opportunities, it asks what is to be accomplished by spending energy on a given use. The task-oriented approach also encourages consideration of the maximum efficiency that could be achieved in getting the job done rather than simply improving the efficiency of methods and devices now in use.

Most important, unless the analysis begins with end use, RD&D priorities and funds may be misdirected because possible end use energy savings may not come to light. End use technology improvements are integral to each energy system. Failure to consider end use fully may distort the relative attractiveness of supply and end use conservation technologies.

Ongoing Comparison

An adequate method for building in conservation identifies and evaluates energy RD&D work to be carried out concurrently at different levels in the organization and therefore at different levels of detail, all closely interacting and linked in the overall national planning process. A national plan for energy

RD&D evolves and is implemented by planning at the top and all the way down and up the line.

The most detailed comparisons of RD&D alternatives should be made within individual RD&D program offices and at the level of specific RD&D tasks or projects -- for example, competing designs for a heat pump or for a high-Btu coal gasification process unit. The detailed information for top-level comparisons should be a product of this day-to-day research.

At decreasing levels of detail, options should be identified and evaluated in both formulating and implementing the National Plan. At the top, the comparisons and decisions regard the larger system -- for example, alternative liquid fuel, gaseous fuel, or electricity-based transportation systems. To build in energy conservation adequately, information must be brought together at this level in a way which makes possible comparison of all potential RD&D opportunities.

Comprehensive Impact Assessment

Comprehensive assessment of energy RD&D options is critical to adequate attention to energy conservation. It has two dimensions: estimating the energy, economic, environmental, and social benefits and costs of competing RD&D options and identifying, evaluating, and comparing all potential technology options on the same basis over each planning period.

Comparing conservation with other RD&D options should produce timely impact assessments addressing major public concerns. By building assessment into energy RD&D effort, conservation and supply RD&D opportunities may be compared to ensure that the most attractive opportunities are not lost.

Principal Findings

In the National Plan, ERDA recognized the need for an approach similar to that outlined above. Measures to improve its planning process, discussed later in this chapter, could greatly enhance the present basis for consideration of conservation. But for the following reasons the analytical and planning processes are not yet adequate:

- o Although ERDA undertook systemwide analyses which considered the possible benefits of end use efficiency improvements in establishing priorities in the National Plan, it has not yet performed a task-oriented, systemwide evaluation of a full range of technological opportunities or made explicit side-by-side comparisons of RD&D options. Improvements in its planning and analysis systems, now being implemented, could provide the basis for the necessary comparisons.
- o Much of the economic, social, and environmental information necessary for comparison of all RD&D opportunities is not available. More important, sufficient research to provide this information is not built into the RD&D of the supply and conservation program offices.
- o ERDA's planning and budgeting are not effectively linked at all important levels. Without such linkage, broad agency-wide decisions about what RD&D should be carried out cannot be translated with confidence into specific research projects.
- o Insufficient policies, planning guidelines, and decision criteria exist for ensuring that all RD&D opportunities, including both energy conservation and supply, are objectively compared.

ERDA 76-1 makes commitments which could solve these problems; work underway in several areas could provide the basis for adequately building in energy conservation. To ensure adequate attention to energy conservation, these commitments should be implemented more quickly. Without such an improvement, ERDA will not be able to make the needed comparisons of technologies within the next 2 years.

ERDA's Building-In Method

This section examines the methods used to formulate ERDA 76-1 and current research of the Office of Conservation Programs.

Description of Choices

The Brookhaven Reference Energy System * -- ERDA's primary planning tool -- can systematically compare the energy costs of alternative systems. It contains sources, technologies, and energy flows from resource extraction through to the end use devices which convert delivered energy (e.g., liquids, gases, solids, or electricity) into desirable forms (e.g., Btu's of residential space heat). Energy efficiency is an important, explicit factor in the RES.

However, there are analyses which go beyond present RES capability, which are essential to a full task-oriented energy systems definition of energy choices. First, the investment costs of the end use devices must be considered. Second, the costs of energy conserving opportunities which go beyond the end use device to more broadly defined energy-using units (e.g., improved home insulations) but are external to the end use device (e.g., the furnace or air conditioner) should be accounted for. They should be included explicitly in the comparisons because they make up a large share of the energy conservation RD&D potential that ERDA anticipates.

Finally, the economics of supply technology affect the economic attractiveness of energy conservation technologies. Levels of end use efficiency (or use efficiency at critical intermediate steps such as electricity generation) considered in ERDA's planning should be adjusted in response to the expected costs of energy supply.

* The data base and computing capabilities are described in ERDA-48, Volume 1, Appendix B. In this report, the term "reference energy system" includes ERDA's entire energy modeling capability.

We recognize the difficulty of developing an analytical approach which accounts for the investment costs associated with the end use of energy. ERDA undertook some preliminary economic analysis including end use costs for the revised National Plan. But much more detailed analysis of the investment costs of promising end use technologies is required. Further, it is important to have the capability to adjust energy efficiency opportunities to reflect changed supply costs.

Evaluation of Choices

Evaluation of energy choices beginning with end use alternatives has three steps. First, the tasks that energy might perform should be described.* Second, the tasks should be examined by searching out a wide range of methods and devices that use different amounts of energy. Third, energy conservation opportunities should be assessed in relation to improvement potential (applying the Second Law of Thermodynamics, for example) rather than to the energy efficiencies of today's end use devices and methods.

The Reference Energy System can calculate the least-cost combination of energy supply options which our economy may be expected to select in the future. But ERDA did not use this capability in formulating the National Plan. Rather, future energy choices were based on six subjectively determined energy futures. Choices represented in these six scenarios were evaluated by calculating manually their impacts on our domestic resources and energy costs. Briefly, the scenarios are: a baseline of no new initiatives, improved efficiencies in end use, synthetics from coal and shale, intensive electrification, limited nuclear power, and a combination of all the technologies.

* In a general sense, this is done. In formulating inputs to the Reference Energy System, ERDA begins by quantifying the services (e.g., automobile miles) that consumers may demand in the future.

Because none of these scenarios reflects the combination of energy choices that the economy may in fact produce, their usefulness in determining an energy RD&D mix is limited. Moreover, excluding the baseline scenario and the one combining all technologies, conservation improvements from new technologies are generally reflected only in the improved end use efficiency scenario. The others varied supply, and although a few items from the conservation scenario were considered, the plan did not carry out the kind of systemwide analysis of supply and conservation opportunities required by a task-oriented approach.

Finally, national planners at ERDA and its end use conservation program offices negotiated the assumptions in the improved end use scenarios. What they negotiated was principally percentage improvements in today's end use devices. Some improvements to be gained through RD&D such as better automobile mileage and industrial plant efficiency were considered. They did not consider the potential of a wide range of new or greatly improved end use technologies which might become available through RD&D.

ERDA did not use its modeling capability because the preliminary results did not appear to be based on adequate data, pointing to another area where major improvements are necessary.

Information Base

Adequate information on the economic, environmental, and social impacts of energy choices is basic to planning. ERDA's impact information reflects three inadequacies:

- o The research that is necessary for environmental assessments of promising technologies, is not built into conservation RD&D.

- o ERDA's economic evaluation capabilities, although its most advanced impact assessment area, require significant improvement to be able to assess the cost impacts associated with alternative RD&D strategies.
- o The information and the analytical capability to identify and compare the impacts of conservation and supply enhancement technologies do not yet exist for the mid- and long-terms.

Identifying and evaluating impacts must be built into each RD&D program.

Impact assessments addressing areas of major public concern should be available on a timely basis, and the assessments should influence what RD&D is carried out. (ERDA's environmental assessment process is discussed in Chapter V and in Part Three.)

Although in general ERDA's economic impact assessment capabilities appear more advanced than its environmental assessment capabilities, they need further development. Since formulation of the first National Plan, the economic impact analysis capabilities have been extended. ERDA 76-1 tested possible impacts of new energy technology on national economic growth and on other conventional indicators of economic well-being. The tests compared new technologies against the alternative of simply allowing energy prices to rise enough to balance demand and supply.

The tests suggest that relying only on price increases to ration limited energy supplies has serious economic impacts. Alternatively, new supply technologies become attractive. We believe that this analysis alone is not sufficient because it does not account for the effect of increased prices on the attractiveness of conservation technologies. Until it does so, ERDA's economic impact information will not be adequate for building energy conservation into energy RD&D.

ERDA's rationale for energy RD&D is providing choices for the future. Energy conservation and supply enhancement should be assessed over comparable periods of time. This type of comparison requires the most reliable possible economic, environmental, and social impact information for all planning periods. The conservation program is not yet generating the information necessary for these comparisons.

Guidance to ensure the generation of necessary impact information and consideration of all the impacts of public concern should be formalized. The procedures should extend below headquarters level where the day-to-day research is done.

Comparisons Throughout Planning

An ongoing comparison process links top-level planning with the detailed planning of research programs and with budget decisions and program implementation. Explicit comparisons of alternative RD&D opportunities are important. When top-level comparisons are made, planning should ensure that costs and benefits of competing technologies are based on detailed research programs designed to produce the results. ERDA's planning approach is inadequate in both respects.

We found that ERDA has made general comparisons of this type in establishing broad agency priorities. However, specific energy conservation and supply enhancement RD&D technology opportunities are not lined up for comparison based on cost, benefit and impact information.

The planning and implementation approach outlined in ERDA 76-1 promises to rank energy RD&D options side-by-side. To do so, ERDA envisions various analyses of energy markets to determine the attractiveness of new energy technology ventures to both private and public investment and the energy-economic-environmental tradeoffs. Program strategy and planning documents are expected to synthesize these studies.

Plans for Improvement

ERDA is improving its agencywide as well as specific program planning capabilities.

Program Planning, Budgeting and Review

The purpose of the PPBR system is to provide "an integrated approach to analyzing future energy technology needs; formulating the federal role in addressing those needs; designing targeted programs to conduct ERDA's portion of the plan; allocating resources consistent with the Plan and program design; and ensuring that ERDA's programs are effectively managed." The components of this approach include:

- . "Normative planning," which establishes broad energy technology goals
- . "Strategic planning," which defines how the goals can be achieved most effectively
- . "Program planning," which describes in detail how the ERDA program will be implemented
- . "Resource allocation," which directs ERDA resources at the most important activities
- . "Program implementation," which delineates the specific activities to be accomplished within approved budgets
- . "Program evaluation," which identifies differences between the operating plan and actual conditions.

Formal documents envisioned by ERDA to accompany these components are listed in Table 7. The PPBR system, an advanced approach to management of a large, complex organization, is still in its early stages.

Better Analysis

Specific actions are being planned to enhance ERDA capabilities for defining systemwide energy choices and for identifying and evaluating energy RD&D opportunities. ERDA plans to:

Table 7: Program Planning, Budgeting, and Review System Outputs

- National Plan for Energy RD&D: documents the comprehensive goals and priorities that help define what should be done if energy problems are to be resolved through technology development (e.g., ERDA-48 and ERDA 76-1).
- Program Strategy: for each technology program, presents major program goals and strategic implementation milestones derived from an analysis of the effectiveness of RD&D in resolving energy problems and the need for a federal role in RD&D.
- Program Plan: details the most cost-effective federal program for implementing each technology program's strategy and specifies how each program will be managed and related to other federal programs.
- ERDA Budget: presents comprehensive near-term priorities and the annual allocation of resources.
- Program Approval Document: a 1-year operating plan, carved out of each program plan, which provides a baseline for monitoring program operations during 1 fiscal year.
- Environmental Development Plan: the EDP outlines the environmental research program planned in parallel with each technology program plan, to resolve environmental issues at a pace consistent with the rate of technology RD&D.
- Environmental Impact Statement: required by the National Environmental Policy Act, conveys the results of the environmental research outlined in each program's EDP to major program decision points.

Source: ERDA 76-1

- o Add the investment cost of alternative end use devices to the Brookhaven Reference Energy System
- o Investigate the macroeconomic impacts of nonprice-induced energy conservation
- o Implement a technique (called "relevance trees") for identifying energy RD&D opportunities and for evaluating and ranking them independent of whether they are conservation or supply enhancement RD&D.
- o Revise the ERDA 76-1 scenarios
- o Consider the use of Second Law of Thermodynamics calculations in its planning and analysis.

Having identified the kinds of analyses needed to support planning, ERDA's next goal is to analyze in more detail programs that are aimed at the same or similar markets. A second goal is to use "tools such as venture analysis, economic impact analysis, tradeoff studies, net energy analysis, and constraint studies [in order to quantify] the costs and benefits of selected energy technologies."

These improvements can result in adequate attention to energy conservation. However, although the work is beginning, RD&D opportunities will not be comprehensively ranked during 1976. With budget leadtimes, with legal restrictions on moving funds among programs, and with multiyear commitments, work planned and budgeted during 1976 will not begin until 1978. RD&D in 1978 may still not benefit from the necessary explicit comparisons of all technologies. ERDA should prepare a detailed action agenda for making needed improvements. Until improved analytical planning methods are used to consider conservation equally with all other options in establishing RD&D priorities, ERDA's National Plan should make clear that priorities will be closely reevaluated annually.

Appendix: An Example of a Task-Oriented Approach

Planning for energy RD&D should evaluate energy choices in terms of complete energy production and use pathways. An essential feature of this analysis is the identification and evaluation of competing energy choices beginning with end use needs.

The earlier discussion of a task-oriented building-in method described one system pathway: from mining coal, step-by-step, through its final use to heat a home. This appendix illustrates an approach to comparisons which encompasses extraction, conversion, transmission, distribution, and end use of competing energy systems. It shows how environmental, economic, and social impacts change the attractiveness of individual configurations of conversion, transmission, and distribution technologies. Equally important, the value of new end use technologies becomes clear. Coal is the source of energy in all the examples given.

Two limitations in this illustration should be pointed out. First, policy planning requires a large number of systematic comparisons in order to identify and evaluate promising technologies. (This example was selected from among several promising coal systems examined by the Council.) Comparisons must also be made across competing fuel systems, for example, coal and nuclear power. Second, the data available for this type of analysis are very limited and are subject to a wide range of uncertainty. Care must be taken in presenting the results of the analysis to identify uncertainties and unknowns.

A Systems Definition of Energy Choices

Residential space heating needs may be satisfied with many different systems configurations.* Geographical variables affect the availability

* To simplify the illustration, we do not consider residential space cooling or other residential energy uses which relate to space heating (e.g., water heating).

and quality of coal, seasonal and annual heating needs, and the technologies at each step from extraction on.

In our illustration a number of individual technical components were combined at each extraction, conversion, transmission, distribution and end use step to form alternative pathways from coal through residential space heat. These technical components were configured for New York, Chicago, and Los Angeles using coal from the east, midwest, and west.* For each coal source and city, economically second-rate pathways were eliminated until the best configuration reflecting four systemwide alternatives remained: direct burning of coal to generate electricity, coal liquefaction, high-Btu coal gasification, and a dual conversion system consisting of an intermediate low-Btu coal gasification conversion step and an electrification final conversion step.**

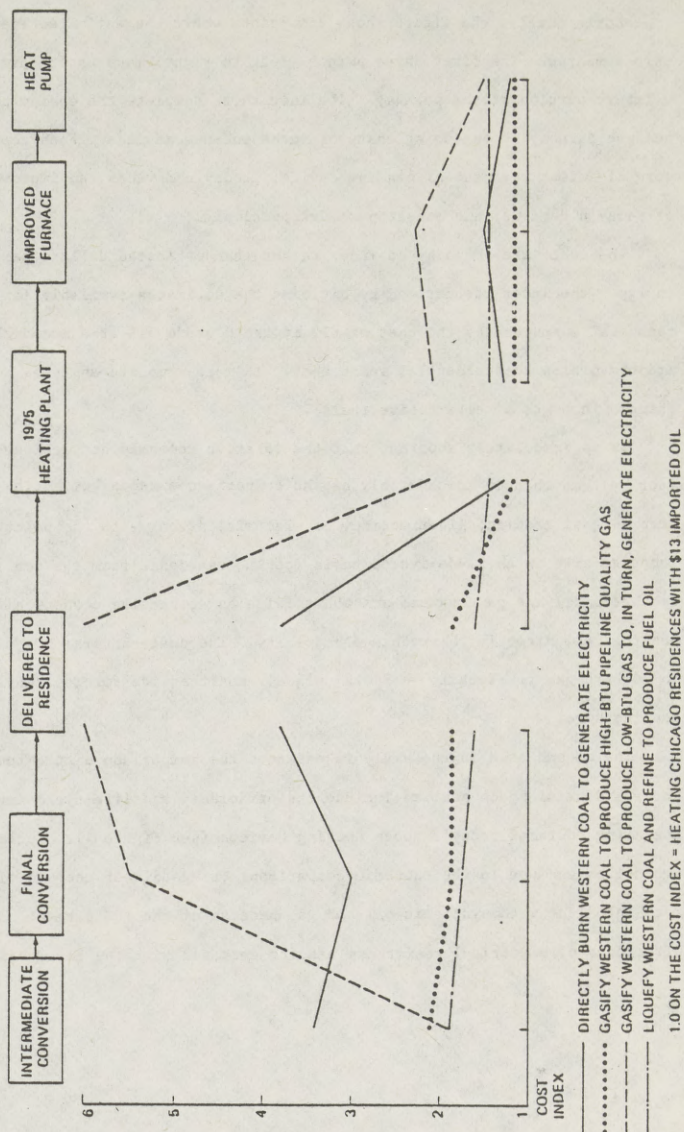
Initially, we compared the four systemwide alternatives to the estimated full life-cycle costs per unit of space heat available in a residence. The comparisons were in three steps: The first began with extraction (coal mining) and stopped with the cost of energy "as delivered" to the residence but before costs of installing and maintaining alternative residential space heating systems were factored in (Figure 4 shows the example results for Chicago).***

* In the interest of brevity, only Chicago is discussed here.

** Of these conversion technologies, coal liquefaction, high-Btu gasification, low-Btu gasification, and improved direct generation through fluidized bed combustion are the subject of ERDA RD&D.

*** The basis for these estimates is shown in Appendix C.

Figure 4
Economics of Four Coal-Based Energy Systems



Horizontally, the figure shows six points where the estimated energy costs were compared. The first three points (left to right) make up the production and delivery portion of the pathway. The last three complete the energy production and use pathway by including costs of three end-use devices. Each represents a more efficient residential heating device: today's devices, an improved version of today's devices, and a heat pump, respectively.

The costs are shown by an index rather than estimated dollars per unit of energy. The index was derived by dividing the estimates available for each technical component by the cost of \$13 imported crude oil at a comparable step in its conversion to residential space heat. (A more complete analysis would consider changes in costs of alternative fuels).

It is immediately apparent that the relative economic attractiveness of the four systems changes considerably as the comparison extends beyond the conversion step -- gasification, liquefaction, or electrification -- to the point of use. Compared only on an as-delivered basis (to the residence from the coal), the coal-synthetic oil and gas systems are about twice as attractive economically as burning coal directly to produce electricity. The dual-conversion system -- coal to low-Btu gas to electric -- looks uniquely unattractive for residential space heating here.

The second step in the analysis extended the comparison of the four choices for residential space heat to include the efficiency and life-cycle investment and operating costs of today's space heating devices (see Figure 4). Including production and use in the economic comparisons brings direct coal to electricity more into line with synthetic oil and gas because of the 100 percent end use efficiency of electrical resistance heating compared with the lower efficiency

of gas-fired and oil-fired residential heating plants.* Despite its 100 percent end use efficiency, the dual-conversion system looks inferior.

In the one case, a system with higher delivered energy costs before end use becomes more economically competitive when its higher end use efficiency is considered. In the other, a 100 percent efficient end use device does not make economic sense when supplied by a high-cost dual conversion energy pathway. The need for systemwide analysis of energy choices is clear.

A question remains about whether new energy conservation technology can improve the overall economic performance of these four systems or change their relative economics. To illustrate, the analysis next considered more efficient oil and gas heating plants as well as an electric heat pump** (see Figure 4). Without a heat pump, more energy efficient gas and oil heating plants lower total costs per unit of space heat. Better furnaces decrease the relative economic attractiveness of the electric configurations, again because electrical resistance heating is already 100 percent efficient at the point of end use.

Adding a heat pump, however, makes the direct coal-to-electric configuration economically comparable to coal synthetics for Chicago's space heat needs. It should be noted that the dual-conversion low-Btu gasification-to-electric option may also approach the economically competitive range for purposes of deciding what RD&D technology candidates to pursue.

It is important to reemphasize the problem associated with these economic comparisons. The cost estimates are often subject to large uncertainties. For

* This 100 percent level should be interpreted as a relative measure of efficiency for well-insulated electrically heated homes, against which gas- and oil-fired systems may be compared.

** A natural gas actuated heat pump was excluded because initial costs lower gas heat economic feasibility. Again to simplify, the illustration excludes new end use technologies potentially capable of affecting gas heat like the way that heat pumps affect electric heat, for example, solar-assisted gas heating systems.

instance, cost estimates for coal liquefaction and gasification plants are not based on proven technologies, since commercial-scale plants have not yet been built in this country. Thus, many of the assumptions used in making these estimates may turn out to be in error.

Comprehensive Impact Assessment

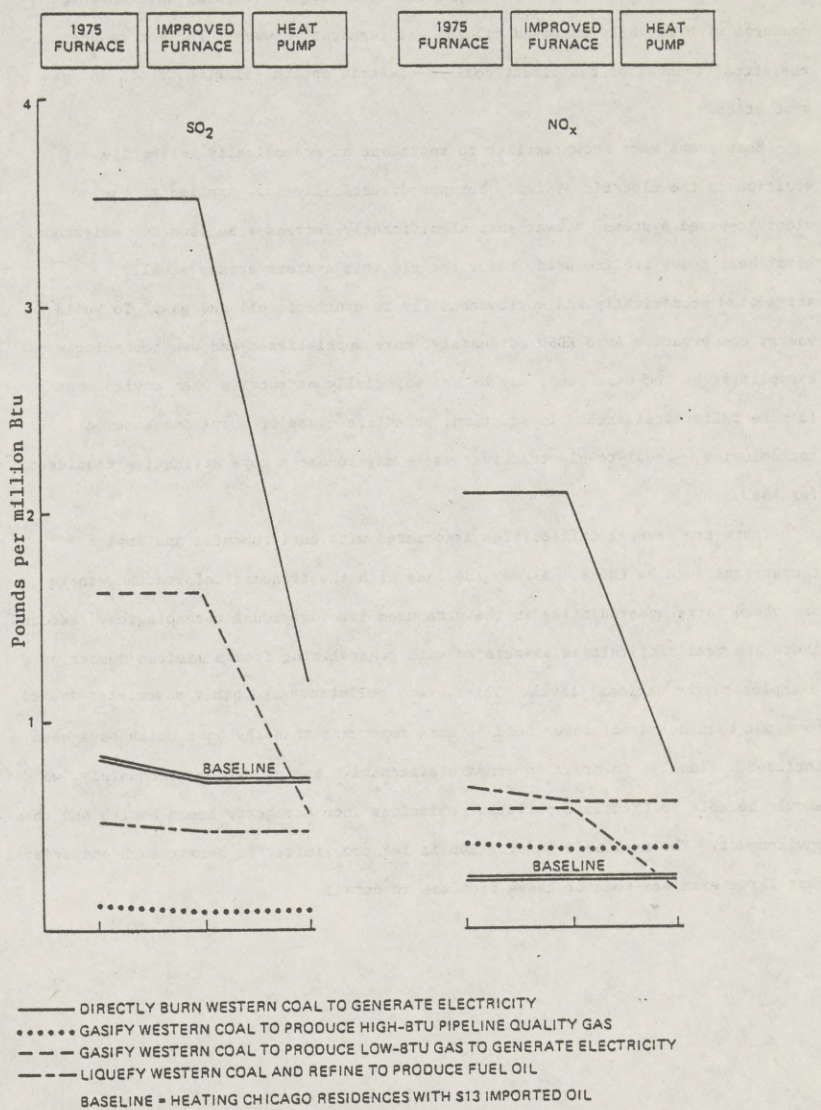
Energy costs alone cannot adequately reflect impacts of energy RD&D options. For example, the four residential space heating systems have other economic, environmental, and social impacts which should be compared comprehensively. The environmental quality assessment illustrates the need for comprehensive impact measures.

The four systems that produce residential space heat from coal also produce different land, air, and water pollutants. They occur at different geographical locations, all with potentially unique vulnerabilities to each pollutant. In the example, environmental impacts of only two air pollutants are considered -- sulfur dioxide and nitrogen oxides, and to simplify, total pounds of SO_2 and NO_x emitted will be used as the measure. Like the economic comparisons, environmental comparisons are made before and after energy conservation technologies are added (see Figure 5).

These two environmental impacts influence the relative attractiveness of the options for meeting Chicago residential space heating needs with coal. Considered before energy conservation improvements, two technologies -- liquefaction and high-Btu gasification -- stand out as especially advantageous economically and environmentally. They also produce less SO_2 than today's oil-based heating systems. In contrast, before-conservation comparisons add environmental disadvantages onto the economic disadvantages of the direct-coal-to-electric system.

Figure 5

Environmental Impacts of Coal-Based Residential Heating



More important, energy-use efficiency improvements can have a major effect on the relative environmental position of the four competing systems. Further, improving today's heating plant moved all but the dual conversion system (low-Btu gasification to electric) into a comparable cost range. Coupling environmental measures with slightly improved oil and gas furnaces, however, further reduces the attractiveness of the direct coal-to-electric option relative to oil and gas synthetics.

Heat pumps were shown earlier to represent an economically worthwhile addition to the electric systems, but not dramatically so. Applied to the electric-based systems, a heat pump significantly decreases SO_2 and NO_x emissions. After heat pumps are included, then, the electric systems appear equally attractive economically and environmentally to synthetic oil and gas. To build energy conservation into RD&D adequately, more sophisticated end use technologies, exemplified by the heat pump, may become especially attractive when environment is more fully considered. In addition, an entire class of supply enhancement technologies -- coal-to-electric systems -- may become a more attractive candidate for RD&D.

There are several difficulties associated with environmental and impact comparisons such as these. As was the case with the economic information, there are often large uncertainties in the data used for individual technologies. Second there are real difficulties associated with generalizing from a limited number of examples to the national level. Third, many pollutants and other associated impact have not been measured; some could be more important than the ones which have been included. Finally, in order to compare alternative energy systems adequately, we should be able to translate pollutant emissions into damage to human health and the environment. The available information is far too limited to permit such comparisons. Part Three examines some of these problems in detail.

The intent of the coal-Chicago illustration is to show that systematically addressing additional impacts of competing RD&D options changes their relative value significantly. The illustration is clearly incomplete for deciding what energy RD&D should be carried out. Addressing other environmental, macroeconomic, and social impacts would provide more insight into different kinds of opportunities for RD&D and could reorder the ranking of opportunities. The Council suspects that doing so would strongly favor energy conservation RD&D.

Chapter V

CONSERVATION PROGRAM DEVELOPMENT

Perhaps the most critical facet of building conservation into energy RD&D is development of the research programs. Individual program design must consider the energy needs that a technical option can fulfill, anticipate RD&D uncertainties, and provide a likelihood of technical and commercial success. To do this, conservation program planning should:

- o Develop and use search and screening techniques for identification of high-payoff conservation RD&D opportunities.
- o Establish a work planning procedure which focuses on individual high-payoff opportunities and ensures the availability of sufficient resources to resolve technical uncertainties.

Energy conservation offers substantial environmental benefits. Special care should be taken to develop environmental and other impact information on conservation technologies for use in identifying and comparing RD&D opportunities. The desired result is a well-organized RD&D program with a clear planning strategy, focused on the best opportunities and giving special attention to their weak spots.

Principal Findings

The Office of Conservation Programs, established in early 1975, combined program objectives, legislative mandates, and program direction and resources from a number of other federal agencies. During the past year and one-half, the office has undergone several changes in leadership and priorities. In preparation for ERDA 76-1, for example, planning emphasis shifted almost entirely to the near term, paying little attention to potential longer-term RD&D opportunities.

During formulation of the current National Plan, five distinct RD&D programs existed within RD&D's Office of Conservation Programs. Although intended to meet the overall conservation objectives of ERDA, they must compete for limited resources. Five individual conservation programs -- planned independently, and using different assumptions, analyses, and decision criteria -- cannot adequately build energy conservation into the agency's decisionmaking process. A common approach is ultimately required.

ERDA is making important progress in developing its conservation RD&D, particularly for end use technologies. But the Council is concerned that a coherent strategy and planning approach are not apparent. Specifically,

- o The search for RD&D opportunities is ad hoc and is not uniformly applied over all time periods. It lacks the context of a long-term conservation strategy and does not employ innovative techniques to identify potential efficiency improvements. The method for screening RD&D options for inclusion in the program is more sophisticated but it lacks benefit, cost, and risk information.
- o A reasonably workable and sophisticated technique is used to screen research options, but it lacks benefit, cost, and risk information.
- o Design of the research programs does not ensure concentration of resources on the most promising opportunities over the several time periods or in sufficient depth to resolve technical uncertainties.
- o Environmental impact information sufficient to compare RD&D options does not exist and is not being generated by the conservation programs.

A major effort is required to correct these deficiencies in conservation program planning. ERDA recognizes this need. The Office of Conservation Programs plans to develop information on individual program benefits, costs, and risks and to develop a better screening technique to use the information. Our question is whether the improvements are receiving sufficient priority. If conservation programs are to meet the high priority objectives ERDA has

established in the near term, and if longer-term programs are to evolve in balance with supply-oriented programs, major improvements must be made within the next 2 years. Once again, we believe that the pace is too slow to meet this goal.

RD&D Search Techniques

Identifying conservation RD&D opportunities is a first step toward an adequate conservation research program. A search technique is simply a label for the activities that culminate in RD&D ideas.

Presently ERDA's search capabilities are inadequate in three respects:

- o Basic techniques have not been identified for mid- and long-term energy conservation RD&D opportunities.
- o In the near-term, where conservation search efforts have concentrated, the search process has been ad hoc -- it lacks the context of formal energy conservation program plans and strategic plans.
- o Basic information, such as comprehensive efficiency potential data, for identifying mid- and long-term opportunities, is not being developed.

Earlier in the report we observed that conservation opportunities reflected in the National Plan are measured solely against the efficiency of today's energy use devices. We suggested use of Second Law of Thermodynamics principles as a way of reflecting maximum feasible potentials. Because it does not consider economics and does not identify specific technologies, this kind of theoretical calculation simply defines upper limits.

At the program planning level the search should take a next step, identifying specific technology opportunities to fill the gap between today's energy efficiencies and the ideal thermodynamic efficiency. From an R&D perspective, this step is a familiar one, and methods exist to aid in the

search for RD&D opportunities. They vary from reliance on the consensus of experts to the kind of systems analysis called for in ERDA 76-1 to support its strategic planning.

The end use energy conservation programs have devoted substantial effort to identifying RD&D opportunities for the next 5 years. Giving this immediate period high priority attention may have limited the search for mid- and long-term opportunities. The principal planning results thus far have been 1-year operating plans (Program Approval Documents) extending through August 1976. Until a longer-term strategy for all ERDA's energy conservation activities is developed, the search for conservation opportunities will be limited.

Most important to ensuring adequate focus in conservation RD&D, however, is that the search be explicit and orderly. ERDA should develop a formal search technique and require its regular and uniform application throughout the Office of Conservation Programs to identify specific RD&D opportunities. They should be linked to an evaluation of their relative desirability and, ultimately, to ERDA's program plans and strategic plans.

RD&D Screening Techniques

A screening technique is a companion of the search technique. Screening applies intuition, information, and formal analysis to potential technological opportunities in planning energy conservation RD&D.

The purpose of a screening technique should be to organize potentially attractive energy conservation RD&D opportunities into major research work areas and subsidiary projects and to rank areas and related projects. A major objective is to decide which opportunities are appropriate for federal RD&D support. The first step is calculation of specific energy requirements that conservation RD&D might meet. Then benefit, cost, and risk information

should be matched with policies, planning guidelines, and decision criteria in order to evaluate the opportunities. Results of the screening should be available to independent review.

The conservation office evaluates RD&D opportunities using 10 broad criteria, shown in Table 8. Individual opportunities are scored numerically and the totals compared. This initial screening is useful. Of course, not all the factors and assigned weights apply equally to all parts of ERDA's energy conservation RD&D program. The idea of using specific criteria as indicators of the kinds of technical insights and analyses needed for evaluation is sound, but we believe that ERDA's screening needs substantial improvement in two key areas:

- o The benefit, cost, and risk information necessary to a useful screening technique has not been developed.
- o Screening is limited to individual energy conservation RD&D contract proposals because of energy conservation's near-term orientation and its lack of strategic planning.

The major problem is too little information. In project evaluation, energy savings estimates are simple allocations of the total savings estimated in the National Plan. If estimates were specific to each RD&D opportunity being evaluated, the screening would be more meaningful.

Another problem relates to use. The technique is used almost entirely in first-step evaluation of individual project proposals. Without an overall program design, the Office of Conservation Programs solicits proposals and then evaluates whatever results with this screening technique. The process is just the reverse of what it should be.

Table 8: ERDA Criteria for Screening Conservation RD&D Opportunities

Energy Savings - 100

Theoretical Potential (40)
Oil and Gas Reduction (60)

Project Marketing and Implementation - 150

Market Penetration Potential (50)
Implementation Time Scale (50)
Degree of Acceleration of Technology Introduction (50)

Economic Viability of Project - 160

Capital Requirements to Implement (40)
Federal Costs to Implement (40)
Payback Time (40)
Downtime (40)

Private Sector Participation - 70

Degree of Joint Funding of Project (20)
Degree to Which Industry is Already Doing Research in the Area (50)

Legal, Social and Institutional Impacts - 50

Impact on Employment (40)
Need for Legislation or Regulation (5)
Regional Program Impact (5)

Impact on Environmental Quality, Health and Safety - 100System Support - 50Other Criteria - 120

Utilization of Waste Products or Heat (40)
Capable of Retrofit (40)
Encourages International Technology Transfer (40)

Other Benefits from Technology - 100Cost/Benefit Ratio - 100

Total Possible Score - 1000

Source: ERDA Office of Conservation Programs

Program Implementation

Once a particular technology is identified for support, steps must be taken to ensure the best chance of commercial success. Analysis of strategies for success will take into account the technical uncertainties to be resolved, the total RD&D investment, and potential consumer savings. The objective is the most economically efficient strategy.

ERDA has not yet developed or employed techniques which approach this objective. The Council believes that there are three major problems with conservation program implementation:

- o Consistent, uniform analysis is not being undertaken to compare and select conservation RD&D strategies.
- o The conservation Program Approval Documents, the only formal expression of the conservation RD&D strategy at the time of ERDA 76-1, do not reflect a coherent, long-term program.
- o Limited decentralization to date may constrain the planning and implementation of conservation RD&D programs.

In our view, a more comprehensive approach to program implementation is required than is expressed in the Program Approval Documents. Conceptually, a PAD is a 1-year contract between the ERDA Administrator and manager of an individual program and it lacks a longer-term program context. As a result, a PAD relates only to short-run activity and includes no rationale.

Program goals and objectives extending beyond the near term should be established.

There is also an organizational obstacle. Unlike supply enhancement, which relies heavily on the national laboratories, energy conservation has not been decentralized. Conservation research has been limited primarily to the small staff of the Office of Conservation Programs, which is divided between program implementation and program development. It appears that the

conservation programs would benefit from decentralization to ERDA's field structure.

Consideration of Environment

Energy conservation technology moderates levels of air and water pollutants and land disruption from mineral extraction and waste disposal. If successful, conservation RD&D can lower total energy consumption and proportionally lower emissions while producing the same amount of work.

To illustrate the environmental benefits of energy conservation, we calculated emission reductions per dollar invested for three conservation technologies being developed by ERDA: the annual cycle energy system (ACES), a Stirling-cycle automobile engine, and industrial heat recuperators.

Specific benefits, of course, depend upon the kinds of energy that are conserved. In general, conservation is likely to displace the more costly energy to be produced by the supply enhancement RD&D being pursued by ERDA. For purposes of this discussion, we assumed that conservation technologies decrease the use of coal-based synthetic gas and oil.

ACES uses a heat pump to transfer heat from a large insulated water tank to a residence in the winter. As the heat is withdrawn, the water freezes. In the summer, the heat pump is reversed and the ice is thawed to provide cooling. The system is expected to reduce the amount of energy used in electric heating and air conditioning by about 50 percent.

The Stirling-cycle automobile engine uses external heat to drive an internal working fluid. An advanced Stirling-cycle automobile engine may reduce fuel use by 20 to 30 percent, depending on auto size, design, and use. Because combustion occurs externally, emissions could be controlled more easily.

Heat recuperators capture the thermal energy that industrial furnaces throw off to the atmosphere (for example, in glass and steel manufacturing). Depending on the specific operation to which they are applied, improved recuperators are expected to reduce fuel use by 80 percent. The energy savings has significant environmental benefits.

Table 9 shows that a \$1 million investment in any of these technologies could result in extensive reduction of pollution.

There is almost no environmental research in conjunction with and directly linked to ERDA's conservation RD&D. ERDA planning has focused on the economic and supply availability consequences of new technologies. Adequate attention to the environment in both conservation and supply RD&D, we believe, would result in a more important role for energy conservation in ERDA's plans.

In the Office of Conservation Programs, assessment of environmental effects has just began. Only a "preliminary environmental review" of current conservation RD&D has been completed. Although the review identified numerous environmental problems, there are no plans for a more detailed research effort (see Table 10). Most important, the studies that are planned or are underway focus on adverse environmental effects (see Table 11). While such studies are important and need to be encouraged, additional efforts are needed to examine the environmental benefits of conservation. A comprehensive environmental assessment and research program linked directly with conservation RD&D should be established.

The remainder of this report discusses environmental planning in detail, including ERDA's program to improve the environmental research related to specific energy technologies.

Table 9: Environmental Benefits of End-Use Conservation (pounds of emissions per day) *			
Pollutant	ACES	Stirling-Cycle Auto	Heat Recuperator
• <u>Reductions at End-Use Sites</u>			
Particulates	-	-	153
SO ₂	-	-	6
NO _x	-	50	6000
CO	-	44	170
HC	-	48	10
• <u>Reductions at Production Sites</u>			
Particulates	16	8	25
SO ₂	330	20	610
NO _x	230	78	240
CO	13	3	13
HC	4	46	4
Land Disruption	1 acre/ day	1 acre/ day	47 acres/ day
* Emissions associated with coal synthetic fuels production and use avoided by an application of \$1 million worth of each kind of more-efficient end-use device. Source: Derived from <u>A Western Regional Energy Development Study</u>, Vol. II (1975); Radian Corporation			

Table 10: Potential Environmental Problems of Conservation Technology

Conservation Technology	Potential Problem
Batteries	Toxic and environmental effects of high efficiency battery electrolytes
Insulation	Environmental consequences of significantly increased amounts of new insulation materials.
Building Standards	Impacts on interior environments of ventilation and the fenestration of energy conserving buildings.
Total Integrated Utility System	Mal-effects of co-location of pollution sources and community centralized utility concepts.
Fuel-Air Mixtures	Effects of increased emissions from more energy efficient fuel-air mixtures.
High Temperature Combustion	Effects of increased NO _x emissions from more energy efficient temperatures and high pressure combustion.
Auto Diesel and Turbine Engines	NO _x , SO _x and efficiency tradeoffs of diesel and turbine auto/truck engines

Source: Preliminary Review of the Energy RD&D Programs of the Office of the Administrator for Conservation (1976); URS Research Corporation

Table 11: Environmental Research Related to Conservation Technology, FY1976

ERDA's Sponsoring Program	Research Description
Biomedical and Environmental Research	Potential health effects of indoor pollution impacts of energy conservation practices. Preliminary studies of waste heat utilization. Evaluation of conservation and other energy alternatives in the Northeast.
Conservation Technology and Research	Monitors of combustion efficiency, pollution emission and noise emission of industrial burners
Transportation Conservation	Economic, environmental and social impacts urban electric vehicles Exhaust emissions of various internal combustion engines with various fuels.

Source: ERDA FY1977 Budget Estimates

Part Three

BUILDING ENVIRONMENT INTO TECHNOLOGY RD&D

The success of any technology ultimately depends upon its acceptance for economic, environmental, and social reasons as well as for energy production. The preceding section on conservation pointed out the importance of considering all attributes of energy technologies in a systems context. This section addresses the adequacy of the attention that energy research and development programs are giving to environmental protection and to the environmental effects of energy technologies.

Assessment of adequacy of attention to environment is somewhat different than evaluation of conservation adequacy. Environmental concerns should permeate all phases of energy research, development, and demonstration. They must be a major consideration for those charged with overall planning and administration of ERDA programs. Although ERDA has an Assistant Administrator for Environment and Safety, the environment should also be a major concern of the other program offices -- fossil fuels, solar, geothermal, and conservation.

The Environmental Protection Agency -- which must develop regulatory standards for new technologies -- shares the responsibility for ensuring the environmental acceptability of new technologies. EPA's environmental research and standard setting programs therefore must be closely coordinated with ERDA's technology development programs.

To build environment into the RD&D planning and decisionmaking process, comprehensive environmental information should be generated for all aspects of the energy technology systems in the RD&D program, and the information should be fully considered in making decisions. This information should be used in selecting the most environmentally acceptable technologies from the

entire range of possible RD&D options and within a particular set of options (for example, coal-conversion technologies). All RD&D programs should demonstrate the following characteristics:

- o Environmental effects associated with developing energy technologies should be systematically assessed and environmental research addressed to priority problem areas.
- o Technology RD&D should be scheduled to reflect availability of environmental research information; environmental research should be keyed to guiding hardware development; and facilities for development and demonstration should be designed to produce needed environmental data.
- o Decisionmaking for RD&D should incorporate procedures for ensuring that all necessary environmental information is available and that it is weighed in making commitments to technology development.
- o A system of checks and balances should exist to ensure that environmental information is developed when needed and that it is fully used as technologies proceed toward commercialization.

These characteristics are all closely related; yet by itself each is important. They underlie our evaluation of adequacy of attention to the environment. We believe that programs exhibiting these characteristics can provide environmentally acceptable energy technologies.

ERDA's National Plan recognizes that environmental protection and enhancement are concepts which "must be fully integrated into energy production and use." The National Plan makes a commitment to an environmental policy strategy which, while lacking detail, appears to include most of the characteristics set forth above. It also outlines the elements of an environmental planning system. These are important steps on ERDA's part toward adequately building environment into its technology programs.

As noted earlier, this evaluation ends with the first quarter of 1976. As of that time, the environmental strategy had not been implemented nor had

procedures been issued for the environmental planning system. Yet many technologies are proceeding toward the later stages of development. In our view, implementation is too slow.

In the absence of an overall environmental strategy and plan, this evaluation necessarily focuses on existing programs. Although steps are being taken to build environment into RD&D, there are serious deficiencies and problems in terms of the characteristics listed above. At the same time, ERDA is aware of the need for improvement.

The following chapters examine these characteristics in detail, evaluate the progress that ERDA and EPA are making toward building environment into technology RD&D, and discuss the improvement efforts that these agencies have planned or have underway. As explained in Chapter I, the coal-related programs are examined in detail; future reports will look at other programs.

Chapter VI

ADDRESSING ENVIRONMENTAL CONCERNS

The foundation of building environment into the energy RD&D process is an ongoing, systematic evaluation of the environmental problems and uncertainties associated with the technologies being developed and an environmental research program to address them.

Environmental evaluation of each technology must be based on the major elements of the environmental research process:

- o Characterization - chemical and physical identification and measurement of the products and byproducts of the entire energy system associated with a technology
- o Effects - definition of the impacts of the products and byproducts of entire energy systems as they are transported to and through and transformed by the physical, biological, and socioeconomic environment
- o Control technology - development of the means to reduce any undesirable effects of the process or associated activities in a system
- o Assessment - integrated evaluation of effects and alternative control technologies to determine the environmental acceptability of the technologies and to establish the need for and feasibility of regulatory standards.

After technology-related environmental problems and uncertainties are identified, environmental research priorities -- emphasis, funding, and timing -- should be established. Factors such as severity of possible environmental impacts, current knowledge, influence of additional information on development decisions, and information required to set environmental and occupational health and safety standards should be examined.

Failure to identify the environmental problems and uncertainties can result in the development of technologies which are environmentally unacceptable; it can also result in lengthy and costly delays in commercialization of otherwise acceptable hardware. Further, sufficient information may not be available to set standards for environmental protection and occupational health and safety.

Without priorities, it is difficult to concentrate available resources on the most important environmental concerns. Devoting some resources to every problem risks not devoting enough to the most important ones.

For each proposed technology, we believe that the energy research and development program should:

- o Systematically identify points in the entire energy system where potential problems may exist and assess the impacts at each point if the technology were developed and commercialized. Assessment requirements should be clearly established.
- o Establish environmental research priorities to ensure that critical problems and uncertainties associated with each technology are considered in the environmental research program
- o Provide the basis in the technology development programs and related environmental research for establishing environmental standards.

This evaluation and priority-setting process must be evolutionary. As more information is developed, the research program should be adjusted and priorities should be reassessed.

Principal Findings

Until recent years, little attention was given to identifying the environmental problems associated with developing nonnuclear energy technologies. Until publication of the interagency RD&D report in 1973

and the two interagency studies which supplemented it,* there was little federal effort related to environmental problems of nonnuclear energy technologies. Since 1974 the federal environmental research program has devoted much more effort to the environmental problems and uncertainties of these technologies. But a well-defined and coordinated federal program for addressing these concerns does not yet exist.

- o There is not an effective, systematic approach to identifying priority environmental problems and to establishing a research program specifically related to developing technologies.
- o Coal technologies now being developed contain many hazardous substances in their process streams. The presence of these substances is poorly understood, and there is too little information on health and ecological effects. Possible effects from the end use of synthetic fuels is receiving only limited attention.
- o Individual coal technology RD&D programs lack a coherent approach to environmental concerns. Research to characterize pollutants from developing coal technologies and to identify potential health and environmental problems is not adequate.
- o ERDA and EPA have not developed procedures for setting environmental and occupational health standards for new coal technologies. Overall interagency cooperation and research coordination need major improvement.

Both agencies are aware of these shortcomings. When current environmental planning is complete, it may reverse the situation. But most of these efforts are just beginning, and until sound environmental research priorities are established, we have no assurance that the technologies under development will

* The Nation's Energy Future (the Ray Report) published in December 1973 was supplemented in November 1974 by the Report of the Interagency Working Group on Health and Environmental Effects of Energy Use and the Final Report of the Interagency Working Group on Environmental Control Technology for Energy Systems, which prescribed requirements for additional environmental research to accompany a new energy R&D program.

be environmentally acceptable. This is a difficult task, but it is one which deserves immediate, high-priority attention. We believe that these problems are not receiving the high-level attention that they require.

Environmental Assessment and Research Priorities

Because it is important to address environmental problems and unknowns, the Council examined possible methods of assessment and applied one method to coal conversion technologies.* We then identified the more significant environmental issues in current programs.

An Assessment Approach

The value of a systemwide approach to generating comprehensive environmental information and evaluating energy technologies is illustrated in the Appendix to Chapter IV. Looking at the entire sequence from untapped resource to end use reduces the likelihood of passing over critical environmental R&D needs (see Figure 6). ERDA 76-1 recognizes the desirability of this approach, and the Brookhaven Reference Energy System, ERDA's principal planning tool, has the capability of doing this type of analysis.** However, the information for energy technologies now in RD&D is incomplete and speculative, because none has been operated at full scale.

In order to understand the environmental aspects of new technologies, one must evaluate each step leading to end use of the energy resource for possible adverse impacts. Figure 7 illustrates the assessment approach that we used.

* "Evaluation of Environmental Research and Development Relative to Coal-Using Technologies," prepared for CEQ by the Energy Resources Company, Inc., Draft Report, April 1976.

** It is based on work supported by ERDA and CEQ; see MERES and the Evaluation of Energy Alternatives.

Figure 6

A Coal-Based Energy Supply System

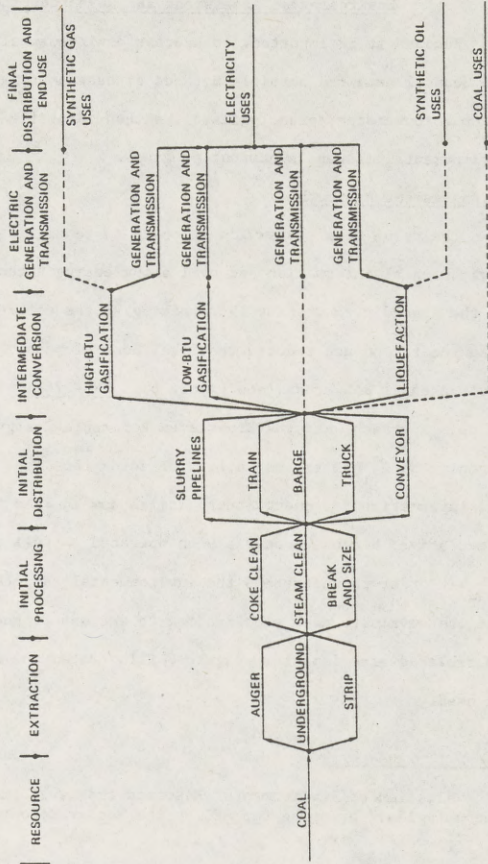
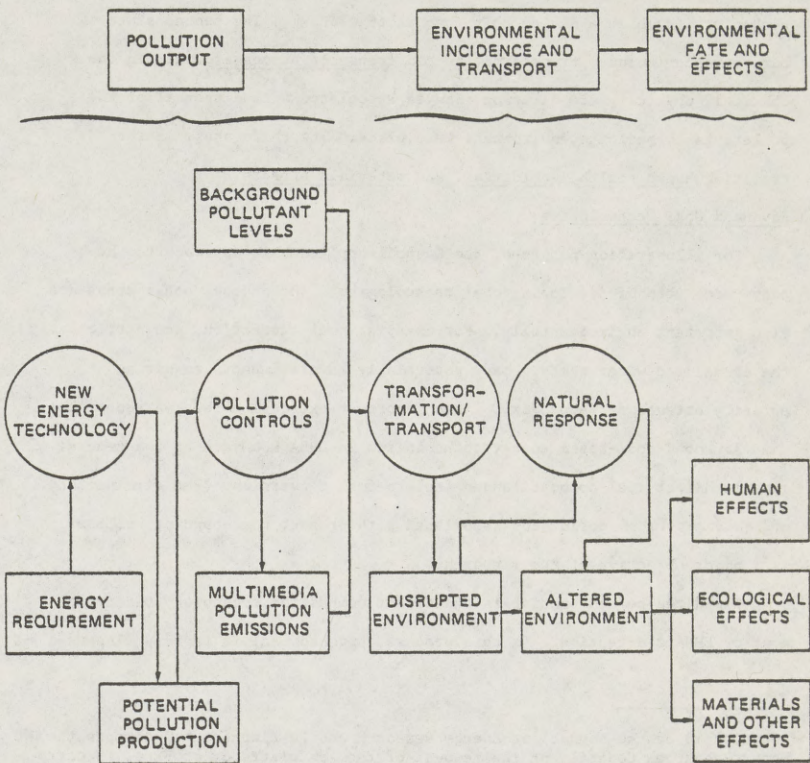


Figure 7
Components of Environmental Assessment



This approach has three general stages: pollution output, incidence and transport of the pollutants, and environmental effects. R&D needs associated with the first stage include process characterization, that is, characterization of all emissions emanating from a process (the process could be mining, transport, or direct burning of coal). The residuals or pollutants are then changed in form and quantity by application of control technology (such as a device to remove particulates). The second stage of our approach includes transformation and transport processes, wherein the chemical, physical, and dilution changes associated with dispersal of the pollutants through the environment take place. The third stage is the resulting human health, ecological, and materials effects.

Advanced Coal Technologies

For illustration purposes, the Council applied this approach to the conversion step of developing coal technologies. (Of course, other steps are also important environmentally. For example, coal extraction, and particularly the associated water needs,* have potentially severe impacts requiring priority attention. (Appendix D lists important extraction-related research.)

Advanced coal-based energy technologies in ERDA RD&D are of two general types: direct coal combustion and fuel-to-fuel conversion. The elimination of sulfur-related pollutants associated with present coal-burning boilers is a major objective of the research.

Fluidized bed combustion is the direct combustion technology receiving most of ERDA's attention. In this process, crushed coal is rapidly dispersed

*Section 13 of the Nonnuclear Energy Research and Development Act directs the Water Resources Council, at the request of the Administrator of ERDA, to carry out comprehensive (national) and site-specific assessments of water availability and of the impacts on water demand associated with new energy technologies.

in a boiler by air blown uniformly through a grid plate; thus it becomes "fluidized." Tiny limestone particles, which are not combustible, are injected; they act as acceptors of the sulfur dioxide. Nitrogen oxide emissions can also be reduced to low levels.

As an alternative to direct burning, production of low-sulfur gaseous and liquid fuels from coal is under active research and development. Gasification involves the reaction of coal with air, oxygen, steam, or a mixture of both to yield a combustion product containing, but not limited to, carbon monoxide, hydrogen, methane, and nitrogen -- and little or no sulfur. The energy content of the product ranges from about 125-175 Btu per standard cubic foot for "low-Btu" gasification processes to about 900-1,000 Btu/scf for "high-Btu" gasification processes. The latter is comparable to the energy content of natural gas.

Liquefaction processes change coal into a liquid fuel while removing most of the ash and sulfur which pose environmental problems. Reactions in liquefaction processes take place at lower temperatures and often at higher pressures than in gasification.

Numerous potentially hazardous substances are expected to be present in advanced coal conversion process streams (see Table 12): lung irritants (e.g., sulfur dioxide and nitrogen oxides), known or suspected carcinogens (nickel carbonyl and beryllium salts), and others with known serious health effects (e.g., mercury and vanadium).

Focusing the Research Program

If a process produces and releases significant amounts of such substances into the environment, serious health and ecological effects can occur. Our understanding of the presence of these substances and of their potential health and ecological impacts is extremely limited. To establish the

Table 12

Potentially Hazardous Substances from Coal-Conversion Technologies¹

MORE POORLY UNDERSTOOD	
Higher Significance	Lower Significance
<u>Benzene</u> - Suspected to cause leukemia <u>Beryllium</u> - Suspected to cause bone and lung cancer <u>Cadmium</u> - Possible relation to prostate cancer <u>Fluorides</u> - May increase sensitivity to chemicals affecting central nervous system <u>Lead</u> - Suspected occupational carcinogen <u>Nickel</u> - Occupational cancer incidence. <u>Nickel Carbonyl</u> - Causes lung cancer; possibly asthma <u>Nitric Acid</u> - Can irritate eyes, lungs, mucous membranes, skin and corrode teeth <u>Nitric Oxide</u> - Can cause pneumonia, circulatory system damage; suspected respiratory irritation and tooth corrosion <u>Nitrogen Dioxide</u> - Suspected to reduce resistance to bacteria; acute exposure causes increased respiratory inhibition <u>Phenols & Cresols</u> - Occupational develop skin cancer; may damage central nervous system and liver <u>Selenium</u> - Occupational cause of digestive and nervous disorders <u>Sulfur Dioxide</u> - Correlates with chronic respiratory diseases; synergistic effects with particulates <u>Zinc Chloride</u> - Possibly carcinogenic	<u>Carbon Monoxide</u> - Suspected to alter enzyme activity; cause behavioral changes; and precipitate heart attacks <u>Fluoride</u> - Suspected association with blood disorders <u>Manganese</u> - Causes brain damage and pneumonia in high doses <u>Xylene</u> - Inhibition of electrical activity in cerebral cortex at levels below odor threshold <u>Vanadium</u> - Acute respiratory irritation; chronic ingestion produces systemic symptoms <u>Zinc Oxide</u> - Occupational exposure can cause intestinal, respiratory, skin and nervous disorders
BETTER UNDERSTOOD	
Higher Significance	Lower Significance
<u>Beryllium</u> - Causes acute and chronic respiratory disorder from short-term exposure <u>Chromium</u> - Suspected cause of lung cancer <u>Fluorides</u> - High levels lead to chronic poisoning or fatality; can cause respiratory impairment <u>Lead</u> - Damages central nervous system <u>Mercury</u> - Damages central nervous system <u>Polycyclic Aromatic Hydrocarbons</u> - Carcinogenic <u>Uranium</u> - Insoluble compounds damage lungs; salts damage kidneys and arteries	<u>Arsenic</u> - Lethal at high doses <u>Barium</u> - Eye, nose, throat, skin irritant; salts and sulfide poisonous <u>Beryllium</u> - Causes chronic berylliosis <u>Cadmium</u> - Systemic and fatal effects from inhalation of high concentrations <u>Carbon Monoxide</u> - Causes dizziness, fatigue, and coronary dysfunction <u>Chromium</u> - Occupational exposure causes lesions of skin and mucous membranes <u>Cyanides</u> - High concentrations lethal <u>Phenols and Cresols</u> - Corrodes skin and mucous membranes <u>Selenium</u> - Causes dermatitis and respiratory irritation <u>Toluene</u> - Chronic exposure can cause brain damage

¹ The basis for the ranking of a substance is a combination of the inherent toxicity of the substance and the degree of human exposure anticipated. The latter is a relative measure, reflecting the increase in concentrations over urban or rural background levels, the concentration expected compared with the level thought to be harmful, and the number of persons who will be affected.

Each effect is placed in the grid according to its ranking of significance and how well it is understood. The list of problems is not comprehensive and does not incorporate all advances to date in the assessment of current knowledge. However, the most important effects are believed to be covered. Some substances are listed more than once depending on the effect and the level of understanding.

Source: Based on Energy Resources Company, Inc., data.

feasibility of coal conversion technologies, detailed priorities must first be set for the research to fill the gaps in our understanding. This is a difficult task. Inevitably there are conflicting views on allocation of resources. Especially when there are many unknowns, wide differences of opinion will exist within a single discipline, not to mention among the disciplines.

In establishing research priorities, ERDA and EPA need to consider:

- o Possible severity of environmental impact: Is the substance known to have significant human or ecological effects?
- o Current understanding: Has the substance been the subject of characterization and effects research; if so, what can be said about the level and type of potential impacts?
- o Effect of additional information on development decisions: Would environmental information alter the course of the technology in the RD&D sequence?
- o Information for environmental and health standards: Is the research basic to establishing regulatory standards for a substance?

Setting research priorities should be a formal -- albeit evolutionary -- process. It involves many disciplines, including those relating to environmental research, technology development, and environmental standard setting.

Major Issues

The Council's assessment of research needs related to coal conversion technologies raises major issues that are fundamental to the commercial success of the technologies now in RD&D programs. This section briefly discusses the issues as a basis for assessing procedures for building environment into RD&D.

Environmental Data - Environmental research must be linked to the technology development programs. As shown in Table 13, environmental data are very limited or nonexistent. This deficiency may be traced to the lack

Table 13: Coal Processes Receiving Federal Support

Process	Development Scale	Size	Environmental Data
<u>COAL CLEANING</u>			
Meyers Chemical Cleaning (TRW/EPA)	Pilot	750 PPH	Some
Physical Cleaning Test Facility (EPA/Burkines)	Pilot	480 TPD	None
General Public Utilities	Commercial	1200 MW	None
EPA Test Support	Commercial	650 MW	None
<u>FLUIDIZED BED COMBUSTION</u>			
Atmospheric Bed (PER)	PDU	Unk	Some
	Pilot	30 MW	n.a.
CPU-400, Gas Turbine (CPC)	PDU	1 TPD (1MW)	None
Pressurized FBC (Esso)	Unk	Unk	Some
Pressurized Bed (IEA)	Pilot	30 MW	None
Pressurized FBC (NRDC/BCURA)	Pilot	Unk	Unk
<u>HIGH-BTU GASIFICATION</u>			
Bi-Gas (BCRI)	Bench	1 TPD	Some
	Pilot	120 TPD	n.a.
Methanator Section	PDU	Unk	Unk
Clean Fuels (Coalcon)	Demo	2600 TPD	Unk
Hydrocarbonization (Union Carbide)	PDU	20 PPH	Unk
CO ₂ Acceptor (CONOCO)	Pilot	40 TPD	Some
Hydrazine (U.S. Bureau of Mines)	Bench	12 PPH	Some
	Pilot	25 TPD	Unk
Hygas (IGT)	Pilot	75 TPD	Unk
Liquid Phase Methanation (Chemical Systems)	Pilot	2 MM SCFD	Unk
Synthane (U.S. Bureau of Mines) (Lummus)	PDU	40 PPH	Some
	Pilot	75 TPD	n.a.
<u>HIGH-AND-LOW-BTU GASIFICATION</u>			
Ash Agglomerating (Battelle Union Carbide)	Pilot	25 TPD	Some
Ash Agglomerating (IGT)	PDU	500 PPH	None
	Pilot	250 TPD	n.a.
<u>LOW-BTU GASIFICATION</u>			
Boiler Fuel Gas (Westinghouse)	PDU	12 TPD	Some
	Pilot	120 TPD	n.a.
Boiler Fuel Gas (Combustion Engineering)	PDU	120 TPD	n.a.
Boiler Fuel Gas (Foster Wheeler)	Pilot	500 TPD	Unk
Flash pyrolysis (Garrett)	Bench	3 PPH	Some
	Pilot	250 TPD	n.a.
Molten Salt (Kellogg)	Bench	unk	Some
Multiple Fluidized Bed (BCRI)	PDU	100 PPH	None
<u>LIQUEFACTION</u>			
CSF (Consol, Fluor)	Pilot	20 TPD	Some
	Bench	20 PPH	None
M-Coal (HRI)	PDU	200 PPH	None
SRG (Pittsburgh & Midway)	Pilot	50 TPD	None
Synthoil (U.S. Bureau of Mines)	Bench	50 PPH	Some
	PDU	10 TPD	n.a.

MM SCFD = million standard cubic feet per day PDU = process development unit

MW = megawatts

PPH = pounds per hour

NA = not applicable

TPD = tons per day

Unknown = information was not or could not be obtained during study

of a comprehensive process characterization research program. The importance of characterization cannot be overemphasized. It is essential to the focus of effects research. Health effects and control technology research cannot be focused until the pollutants emanating from a technology are identified.*

Table 14 ranks research priorities for process characterization. The items are general and do not reflect the priorities and characteristics of specific processes. High priority was given to health-related research areas lacking adequate information for rough evaluation of the technologies. Medium priority was given to both the remaining health-related research and to the nonhealth-related research areas believed to affect technology choices significantly. All remaining areas were classified as low priority.

To date, process characterization efforts have been inadequate. Both ERDA and EPA are initiating studies to improve characterization. Chapter VIII evaluates present efforts.

Information on Health Effects - Table 15 lists some priority areas for health effects research. Briefly, there is too little information to judge almost all effects, except perhaps for the currently regulated "criteria" pollutants.** At the present level of understanding, research is needed in almost all categories.

Because with time and budget constraints it is virtually impossible to learn enough to quantify health impacts, screening and toxicological studies indicating the presence or absence of effects and providing qualitative data

* Human health effects were accorded high priority for purposes of this discussion. Our assessment also included ecological materials effects research. Appendix E lists some research needs in these areas.

** The six for which national ambient air quality standards have been designated: total suspended particulates, sulfur dioxide, carbon monoxide, photochemical oxidants, nitrogen dioxide, and hydrocarbons.

Table 14
SOME RESEARCH NEEDS FOR PROCESS CHARACTERIZATION

HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY
Toxic substances in flue gas Trace elements in gasification and liquefaction Effectiveness of acid gas treatment in removing CO_2 and CS_2 Nickel carbonyl in product gas Toxic trace metals in product gas Toxic organics and trace metals in synthetic liquid fuels Relationship of particle size to composition in combustion and gasification Toxic organics and trace species	Retention of sulfur in ash of western alkaline coals Toxic substances from gasification quench water Fugitive emissions from gasification and liquefaction Emissions from tar separation (gasification) Relate emissions to coal composition in conversion processes Toxic metals in char/ash from conversion processes Soil probe to measure leachate High pressure and high temperature sampling apparatus NO_x levels from CFB and combined cycles Dust and organics in coal drier exhaust The sulfur and hydrocarbons in CO_2 stream from sulfur removal plants Emissions from catalyst reaction (gasification and liquefaction) Formation of POM and oxygenated hydrocarbons from direct combustion	Toxic substances in coal preparation solid wastes Toxic substances left in ash from combustion Fugitive emissions from blow-down and condenser cooling water Fluid substances in ash of fluid beds Stone fines leaving fluid beds

Table 15

SOME RESEARCH NEEDS FOR HEALTH EFFECTS

HIGH PRIORITY	MEDIUM PRIORITY
Elucidate dose-response relationships Measure and understand role of co-carcinogens Measure and understand synergistic effects generally Characterize sensitive and resistant sub-populations Develop general species-to-species extrapolation methods Develop rapid screening techniques for identification of toxic substances Develop screening techniques measuring effect of total environmental burden of a process on higher animals Develop sensitive analytic methods for ambient levels and for tissue and organ residues	Compile data on health effects Collect background data on content of specific organics and trace metals in foodstuffs Map diseases; study geographical distribution Study effect of large sudden increases in toxic substance levels due to startup at large coal conversion facilities

Source: Based on Energy Resources Company, Inc.

are especially important. Several critical research needs must be met before screening and toxicological studies can be used to estimate human health impacts with confidence:

- o Screening methods must be refined and limitations of the results established.
- o Species-to-species relationships must be better understood in order to extrapolate the toxicological data on animals to human beings.
- o Methods to measure trace quantities of harmful compounds in air and water and in tissues and organs must be developed.

ERDA's Office of Environment and Safety is working to improve existing techniques, but more emphasis is needed. Its developing health effects program is discussed in Chapter VII.

Coordination of Health Effects and Technology - It is essential that the federal health research program be coordinated with technology RD&D. In short, health effects research should address problems believed to be associated with specific classes of compounds. Some steps are now being taken to effect this kind of coordination.

Related research is conducted not just by ERDA and EPA but by the National Institutes of Health. Many energy-related studies now focus on protection of human health and the environment, but they are generally broad and cover a wide range of impacts. Some address specific effects of identified technologies, but most are more general. It is important to tie environmental research objectives to problems associated with specific technologies.

End Use Health Effects - Linking environmental and technology research programs in a systems context requires looking at impacts not just of the conversion process but also of a product's end use. For example, residential use of synthetic fuels is one research area that seems to be receiving little attention. Synthetic gas plants may use nickel as a catalyst in the last

step of production. Potentially carcinogenic nickel compounds could then be present in the products of coal gasification plants, with consequent effects at the point of end use. Investigation of the carcinogenicity, teratogenicity, and toxicity of several nickel compounds is being funded by ERDA. However, studies to determine whether these compounds are present in the product streams of coal gasification plants are limited. Although nickel carbonyl is being measured for the synthane process, nickel subsulfide is apparently not being studied.

Careful attention should be given to characterizing potentially hazardous substances in the product streams of all synthetic fuel processes and to ensuring that the necessary research is directed at understanding their health effects.

Standard-Setting Focus - One function of the energy RD&D program is to provide information for setting standards under federal environmental control laws (see Chapter II, Table 1). Under these laws new performance standards will be required for many new technologies before they can operate commercially. In addition, ambient air quality standards may be necessary for pollutants not currently regulated by the Clean Air Act.

Data are needed on the nature and magnitude of the emissions or effluents, their potential health and ecological effects, and the costs and effectiveness of alternative control technologies. Research and development should be organized to generate the information needed to develop these standards, not to design facilities that meet only current standards.

Meeting this need will require coordination between ERDA and the regulatory agencies. The research program related to coal technology is not yet adequately organized to develop this information.

The Present Program Approach

We reviewed the environmental planning in ERDA and EPA to determine whether they are comprehensively identifying potential problem areas and translating their findings into priority environmental research. Our general conclusion is that there is yet no system in place and functioning to meet these objectives. However, both agencies are aware of the need to reassess the focus of their environmental research programs and have proposed assessment and planning systems that could lead to the needed, technology-focused research programs.

ERDA's Office of Environment and Safety

Primary responsibility for environmental research within ERDA rests with the Office of Environment and Safety, primarily the Division of Biomedical and Environmental Research. It is responsible for planning and overseeing research projects at ERDA's national laboratories and at universities.

OES's traditional approach to research identification has been to rely substantially upon laboratory and university researchers to propose projects which it then approves or disapproves on an informal basis. More central direction is necessary. Laboratory researchers may have little sense of needs associated with the many new technology programs being instituted by ERDA, and they may well have no idea of the development, demonstration, and commercialization schedules associated with the technologies. For example, beginning in the late 1940's, the AEC carried out extensive research related to the effects of nuclear releases. This research capability would appear to have value if applied to nonnuclear programs, but it has not yet been specifically redirected in a major way. Substantial redirection may begin in FY1978.

OES must base research priorities on its own assessment of technology-related problems. With such a framework, it could better evaluate research

proposals, and, further, it could identify the areas where environmental research is lacking. Equally important, OES could relate the research to commercialization schedules. The office is taking steps which could provide the basis for adequately addressing environmental concerns.

Reprogramming Efforts - The Office of Environment and Safety has directed some environmental research toward the technologies nearest commercialization. New funds were applied to nonnuclear technologies, in particular to fossil fuel technologies. Coal has received the greatest share of these funds (see Figure 8).

OES has also initiated specific problem-oriented efforts which address the total research needs related to a given hardware program. For example, a program in support of coal conversion is being planned for the Oak Ridge National Laboratory to characterize chemical pollutants in process and effluent streams, to identify biologically hazardous agents through rapid screening tests, to determine biological and environmental effects, and to assess health, environmental, and socioeconomic impacts of coal development. The Lawrence Livermore Laboratory is coordinating a program to develop baseline environmental data paralleling development of geothermal energy sources in the Imperial Valley. A similar effort is being planned for oil shale.

These are important steps. Reprogramming should continue to the extent feasible without impinging on needed nuclear-related research.

The Balanced Program Plan - Lacking a comprehensive and detailed central research design, ERDA has initiated the Balanced Program Plan to direct research projects toward the important environmental problems posed by new technologies. The BPP's preliminary allocation of research efforts across technology categories and environmental research categories is summarized in Figure 9.

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Figure 8

ERDA's Biomedical and Environmental Research Budget

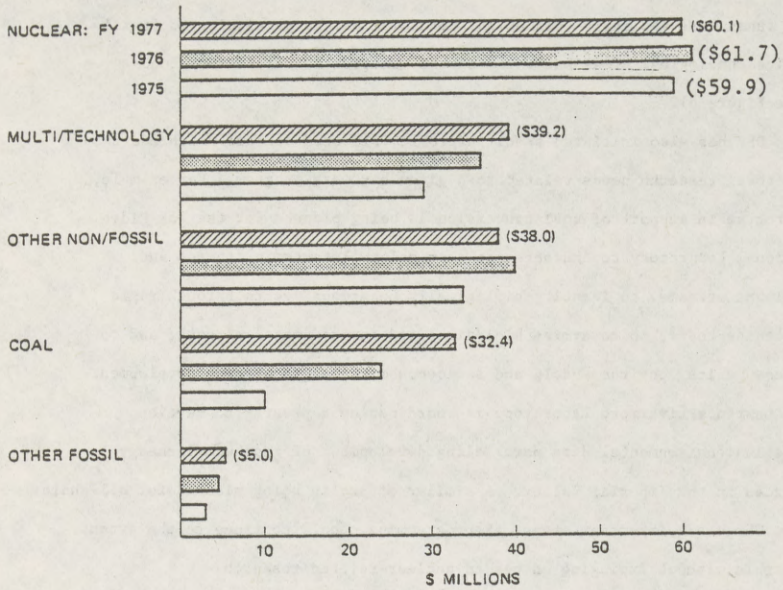
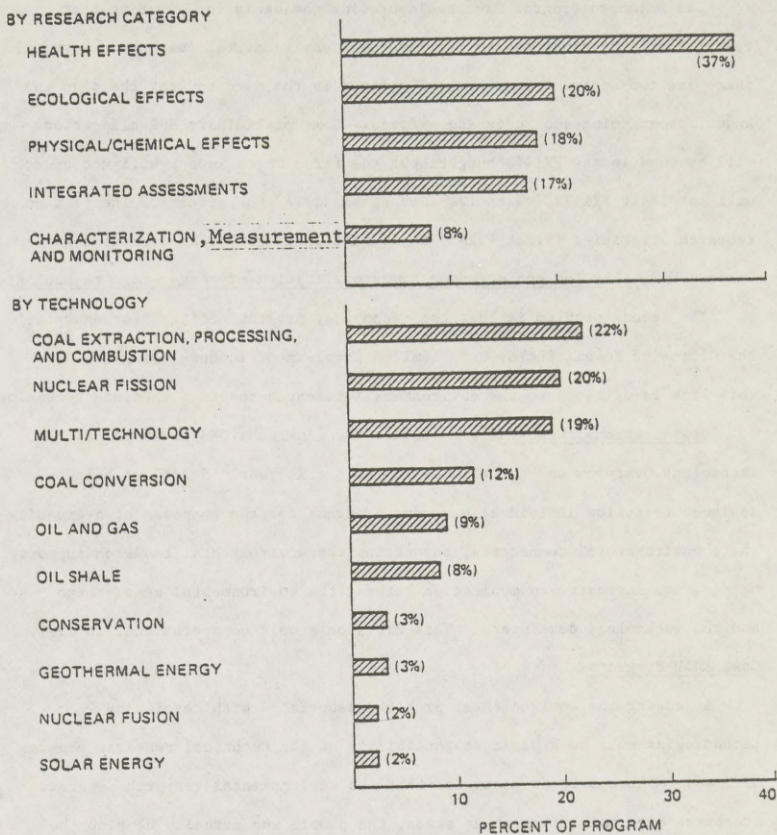


Figure 9

ERDA's Balanced Program Plan Budget Allocations



Source: ERDA/DSER, "Balanced Program Plan: Requirements for Biomedical and Environmental Research" (1975)

The BPP strategy appears consistent with the need to develop environmental information for all new technologies. However, a plan cannot take the place of research. OES has listed more than 1,000 research tasks needed to address the environmental problems identified in its initial planning. These tasks are now being integrated into the schedules and milestones for each energy technology. It is not yet clear how priorities will be established.

The Balanced Program Plan could provide the basis for ensuring that research will be conducted on the important environmental concerns. However, there are two apparent problems. The first is the need to link the plan to annual programming and budgeting efforts. Some preliminary BPP allocations will be used in the FY1978 budget, but the first major impact will not occur until at least FY1979. With its current schedule, the effect of the plan on research priorities is not likely to be felt until 1980. As discussed in Chapter VII, this lag could impede commercialization of nearer-term technologies.

The second problem is that the technology program offices (for example, the Office of Fossil Fuels) have limited involvement in developing the BPP. This link is critical to the environmental research needs of specific technologies.

Organizational Changes - To provide the link, the OES Division of Technology Overview was established in March this year. Staff are being assigned to follow individual hardware programs for the purposes of overseeing their environmental components, advocating the environmental research support needed, and improving communication between the environmental researchers and the technology developers. This division should be operational in 1977.

Coal RD&D Programs

Assessing the environmental problems associated with developing technologies must be a basic responsibility of the technical research program offices. Although it is essential that the environmental research programs concentrate on priority problem areas, the people who actually develop the

technologies must become familiar with and address the environmental problems as the technologies are developed. The coal RD&D programs were examined to understand better the state of environmental planning in ERDA.

Existing documentation of ERDA's hardware development activities is slim. There are no environmental planning documents, and the Program Approval Document prepared for the coal program gives little indication of how environmental concerns will be addressed.

ERDA 76-1, which was prepared after the initial Coal PAD, makes some commitments regarding environmental activities in the hardware development programs. As shown by the quotations in Table 16, however, the commitments are rather ambiguous and inconsistent. It is difficult to gauge how even these limited commitments will work out. As discussed in Chapter VIII, several assessments are in progress.

Much more is required; plans must be detailed and specific. The technology RD&D offices under oversight by the Office of Environment and Safety should establish a complete environmental program for each technology-encompassing assessment, coordination with environmental research and standard setting agencies, and monitoring and control at RD&D facilities.

Contract Requirements - Although technological programs rely heavily on private contractors to design, construct, and operate facilities, contractors do not receive sufficient guidance from ERDA on environmental requirements.

In the coal RD&D program, contractors are given design and performance criteria in requests for proposals and in contracts. A review of these documents for the three synthetic fuels demonstration plants indicates that environmental criteria are too general to direct contractors adequately in design and evaluation of hardware.

Table 16
 ENVIRONMENTAL STATUS OF COAL TECHNOLOGIES
 As Described in ERDA 76-1

TECHNOLOGY	STATUS
LIQUEFACTION	"Existing liquefaction pilot plants comply with all applicable environmental regulations. In addition, environmental monitoring is conducted at all pilot plants.
HIGH Btu GASIFICATION	"The potential environmental impact of large coal gasification facilities is being addressed for both state-of-the-art and second generation coal gasification processes. Two environmental impact statements have been filed in New Mexico on plants employing state-of-the-art processes. One of the major objectives of the pilot plant program is the mitigation of potential adverse environmental impacts.
LOW Btu GASIFICATION	"Although low Btu gasification promotes environmentally acceptable use of coal, there are environmental impacts associated with the processing of coal also. Hot gas cleanup and other environmental control systems are being developed simultaneously to mitigate these impacts.
DIRECT COMBUSTION	"New coal fired facilities are limited to emissions of 1.2 lbs. SO ₂ and 0.7 lbs. nitrogen oxides per million Btu fuel input. Data from process development units indicate that fluidized bed combustors can meet environmental standards. Carbon containing byproducts (char and beneficiation wastes) have been successfully burned in fluidized bed combustors. Modeling activities are under way to predict product and byproduct distributions based on coal composition inputs. Environment and safety design criteria have been fully incorporated into hardware development activities for coal fuel and ash disposal systems, hot gas cleanup systems, and materials development programs for fluidized bed combustion processes."

The contract for the first coal synthetics demonstration facility, for example, contained explicit, detailed requirements for contractor submission of information for an environmental impact statement -- an important step. However, the information required is heavily oriented toward the impact of the facility on the site. The contract is not similarly specific for plant construction and operation; rather, requirements primarily relate to meeting current standards. Although the contractor is "to obtain data which will permit design of an environmentally acceptable commercial plant," how the necessary tasks are to be undertaken is not specified.

Similar deficiencies were found in the requests for proposals for low-Btu and high-Btu gasification demonstration facilities.

The Nonnuclear Energy Research and Development Act directs ERDA to establish contracting procedures to ensure that the environmental impacts of a demonstration facility are fully considered. But the temporary regulations covering proposals for demonstrations simply repeat the language of the act and do not provide detailed guidance on environmental matters.

Providing environmental guidance to contractors in all technology development programs should receive immediate attention. It may be in the form of detailed regulations, manuals of practice which are incorporated into the contract, or actual contract specifications.

Environmental Development Plans - The foundation of ERDA's agencywide environmental planning will be Environmental Development Plans and environmental assessments for each hardware program (see Table 17). The EDP will identify environmental issues, concerns, and problems; analyze available data; and develop a plan for solving the problems, presumably including research priorities. It is intended as a companion to the program plan for each technology.

Table 17

ENVIRONMENTAL PLANNING DOCUMENTS
As Described in ERDA 76-1

Environmental Development Plans

"EDP documents the planning, budgeting, management and review processes for the environmental aspects of each energy technology, and also:

- Assesses the current status of understanding with respect to environmental and institutional problems
- "Identifies major problem areas and topics requiring research
- "Designates significant milestones
- "Specifies requirements for performance monitoring and supporting research

"Definition of the EDP requires close interaction between those responsible for developing the energy technologies and those responsible for ensuring their environmental acceptability. This close coordination will provide the necessary visibility to ensure that all components are compatible."

Environmental Assessments

"The remaining component of the environmental planning process is the Assessment of Environmental Impact, which culminates in the preparation of environmental impact statements at major decision points in a technology's development. This process provides the primary means for identifying and documenting the environmental, technological, economic, and other factors considered in decision-making."

ERDA's proposed requirements for these major environmental planning efforts could provide the basis for building environment into the technology RD&D programs. But procedures for EDPs have not been developed, and full implementation of the program appears at least a year away.

Related EPA Programs

Through its regulatory mission, EPA is involved in assessing environmental impacts of developing energy technologies and in establishing research priorities. Its ultimate goal is to set the standards when and if they become necessary for new technologies. EPA's Office of Research and Development executes the basic environmental research responsibility through its Office of Energy, Minerals and Industry. However, the principal regulatory arms of EPA -- the Office of Air Programs and the Office of Water Programs -- should be closely involved with development and demonstration of new technologies because:

- o At a minimum, pilot and demonstration facilities will be required to meet existing air and water quality standards, and EPA should provide environmental guidelines for designing the facilities.
- o The facilities should be designed and operated to identify and control new potential pollutants. EPA should guide ERDA in meeting these objectives.

EPA's research and regulatory programs are not providing this guidance. The Office of Research and Development recognizes the need for remedial measures and is making improvements, but the regulatory offices should be involved as well.

Environmental Research - EPA's environmental research related to coal-based synthetic fuels includes environmental assessments, process characterization, health effects studies, and control technology R&D.

EPA has plans to characterize effluents of pilot and demonstration plants; success will depend on ERDA's cooperation in providing access to facilities. Biological screening of samples acquired in process characterization is one

step in the health effects research sequence. But as discussed in Chapter VIII, more is required before health-related standards can be established. This area appears to be the weakest link in the EPA program. Further, it is not apparent how this program relates to parallel work conducted by ERDA.

Much of the EPA emphasis is on evaluating the feasibility and adequacy of control technologies. Although this evaluation should be an essential part of its mission, EPA cannot proceed in isolation. Emphasis on control technology, particularly for synthetic fuels, should be closely coordinated with the control technology component of ERDA environmental research and with the technology development programs. Sufficient coordination does not yet exist.

Overall, EPA's environmental research program attempts to address the problems of specific energy technologies, an important step in establishing regulatory standards. However, as discussed in Chapter VII, timing may be a problem. In particular, EPA's synthetic fuels program has a predominantly near-term focus, with published target dates extending only to 1978. EPA recently published a 5-year plan for R&D. This contains no specific research schedules. A longer-term focus is necessary, and the program should be tied closely to the technology schedules.

Guidance for New Technologies - ERDA has the principal responsibility for developing environmentally acceptable technologies, including incorporation of necessary controls in facility design. One of EPA's most important functions, then, is to advise ERDA on construction and operation of pilot and demonstration facilities. Guidance should relate to:

- o Designing and operating facilities with monitoring equipment that can provide the data which EPA needs to characterize effluents for regulatory purposes
- o Control technologies for plants which will be required to meet existing or proposed environmental standards.

The first requires close coordination of EPA and ERDA which does not now exist. Both agencies should give priority to coordination of design for monitoring and characterization.

On the second point, through its proposed Manuals of Control Technology Practice, EPA will describe the best possible pollution control technology for synthetic fuel processes which are commercial or are nearing commercialization. This concept presents a rather fundamental dilemma. Although it is possible that several synthetics processes will be commercialized under the proposed Synthetic Fuels Commercialization Program,* ERDA is also proposing to fund demonstration plants for three advanced coal-based synthetic fuel technologies which are far from commercialization. These facilities may require standards for pollutants which are not currently regulated. Providing full guidance on control of all but currently regulated pollutants is not possible. New ones must first be identified and the need for standards established. ERDA will require information which goes beyond best available control technology for design and operation of demonstration facilities.

Development of this information necessitates a cooperative working relationship between ERDA and EPA. EPA should propose standards for new technologies when there is adequate information to do so. EPA should establish criteria for identification and control of classes of substances which may require future regulation.

* The proposed Synthetic Fuels Commercialization Program, to be administered by ERDA, would guarantee loans to encourage construction of commercial-scale facilities to provide synthetic gas and liquid fuels from coal, oil shale, and waste products. The proposal was developed by an interagency task force. See Synthetic Fuels Commercialization Program, report submitted by Synfuels Interagency Task Force to the President's Energy Resources Council, 1975. Authorization for the program is pending in the Congress.

ERDA and EPA should jointly develop environmental performance goals for proposed demonstration facilities to be used in evaluating contract proposals. Both agencies should monitor and characterize process streams of ERDA facilities to provide the basis for regulatory decisions.

The Interagency Program - EPA administers the Interagency Energy Environment R&D Program. Under this program EPA distributes a portion of its environmental research budget to other federal agencies. Figures 10 and 11 show the allocation of the \$68 million of interagency funds retained by EPA and of the \$31 million passed through to other federal agencies.

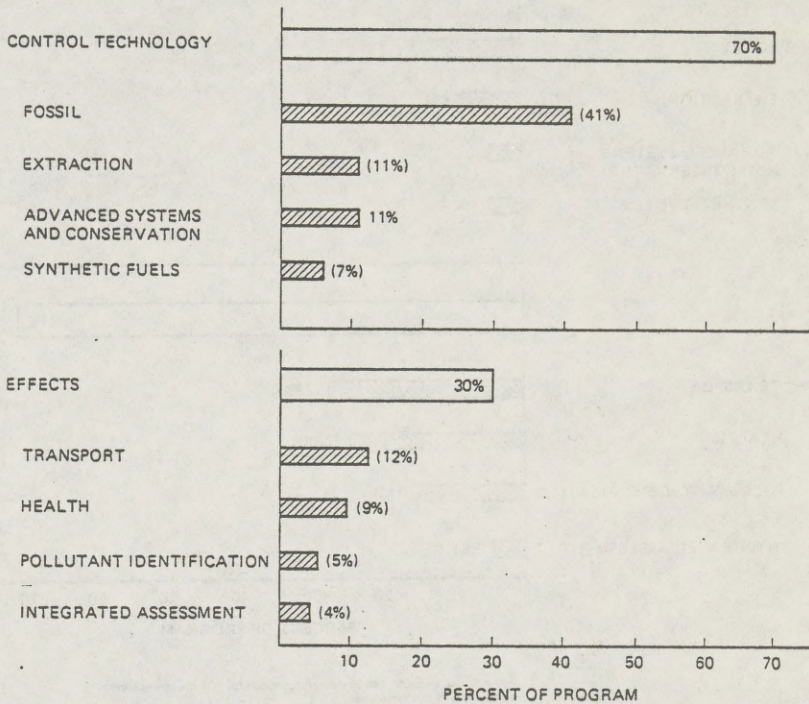
The program, established prior to ERDA and its nonnuclear mandate, is designed to use the expertise of other federal agencies, such as the National Institutes of Health, to address energy-related environmental problems. Funds are distributed according to a formula recommended by the 1973 Interagency Task Force on Environmental and Health Effects Research and Technology.

We did not evaluate the research priorities indicated by the distribution of funds. But it is important to note that in the 3 years since the task forces established the distribution formula, emphasis in nonnuclear RD&D has changed significantly. Entirely new technology research programs have been added, programs then in existence have been expanded or redirected, and ERDA's environmental research program has grown significantly.

Each year the objectives for individual agencies participating in the program are "renegotiated" with EPA, and there has been some shift in program emphasis. Because many of the projects are multiyear, program redirection is difficult, but major shifts should be taken when necessary. EPA recently organized interagency working groups to assist in coordination and planning. They should further aid redirection.

Figure 10

EPA's Energy-Related Research Budget Allocations, FY1976

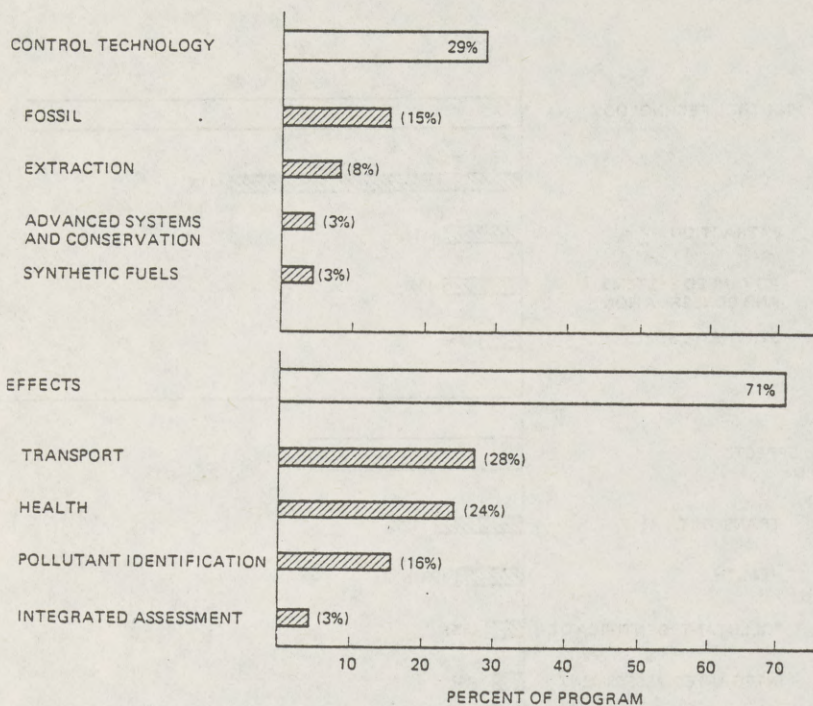


¹Represents EPA-retained share of the Interagency Energy Program

Source: EPA, "Federal Interagency Energy/Environment R&D Program-Status Report II" (1975).

Figure 11

EPA's Energy "Pass Through" Budget Allocations, FY1976



¹ EPA "passes through" 18% of control technology funds in the Interagency Program and 54% of effects funds

Source: EPA, "Federal Interagency Energy/Environment R&D Program-Status Report II" (1975).

Working Relationships and Research Coordination

Our assessment pointed up several areas where good coordination and working relationships are lacking.

Within ERDA the nonnuclear technology development programs and environmental research programs do not have a close working relationship. Between ERDA and other agencies, particularly EPA, ties are limited.

ERDA 76-1 is committed to a "strong and interactive relationship between ERDA and EPA [which] is needed to assist ERDA in effectively integrating its approach to environmental consideration into technology design and to ensure a coordinated federal approach to key environmental issues." However, although ERDA has formal interagency agreements with some agencies, none has yet been established with EPA or with the Occupational Health and Safety Administration. A general memorandum of understanding with EPA is being drafted.

The Council is particularly concerned about coordinating environmental research programs of several federal agencies. Lack of coordination can lead to redundancy and to critical research gaps. In addition, much of the health effects research is very costly. It is presently done by NIH, ERDA laboratories, and, to a more limited extent, EPA.

Although detailed review is beyond the scope of this study, we examined programs related to sulfate formation in the atmosphere as an illustration of coordination problems. ERDA's Office of Environment and Safety is beginning an integrated program (MAP³S, the Multistate Area Power Production Pollution Study), to include field studies of sulfate formation in powerplant plumes. Predictive models capable of relating ambient sulfur levels to sulfur dioxide emissions and new analytic techniques will be developed. EPA's sulfate program also includes field studies, laboratory work, and model development. Aircraft

and ground stations will take samples. Further, the privately funded Electric Power Research Institute is characterizing air quality for sulfates in the Eastern states.

The EPA and ERDA programs are described as complementary at the management level in Washington. Yet there has been only limited program coordination. Efforts are now being made to encourage development of a National Atmospheric Sulfate Program, which would coordinate the three regional programs.

The apparent overlap in the sulfur dioxide-sulfate research programs has the advantage of maintaining multiple agency funding in areas where important national decisions are needed. Independent programs may provide more meaningful results than a single agency expending equivalent funds -- the orthodoxy that characterizes the planning and operational structure of a single agency may inhibit pursuit of alternative approaches to a problem.

ERDA, EPA, and National Cancer Institute carcinogenesis research programs also illustrate the vital importance of program coordination: Based on ERDA analysis, the NCI fossil energy-related health effects research budget approximates the combined ERDA and EPA budget for comparable work. ERDA is attempting to avoid major overlaps through Interagency Collaborative Groups and the development of an annual inventory of energy-related environmental R&D.

The advantages of multiagency programs may be lost in the absence of planning and oversight by a jointly constituted or independent group responsible for overall planning of program objectives and timetables. The entire federal energy-related environmental research program should be examined periodically to ensure coverage of the important problems associated with developing technologies.

Chapter VII

SCHEDULING ENVIRONMENTAL RESEARCH

Timing is important to the adequacy of building environmental factors into energy RD&D. Environmental research should be scheduled along with technology development so that the environmental information is available to guide decisions.

Failure to coordinate the schedule could delay commercialization of a technology. Further, if the information base for environmental standards is not available, the standards set subsequent to commercialization could result in costly controls. It is much better to design environmental controls into a facility from the beginning.

Following these procedures is necessary to coordinate scheduling:

- o Environmental research should begin early and should keep pace with hardware development; plans and schedules should reflect the link between the two.
- o There should be an explicit connection between milestones for environmental research and those for related technology development.
- o Hardware development schedules should reflect a realistic sense of the state of environmental information with timely plans to reduce uncertainties.
- o Standard-setting should be linked to hardware development schedules; ERDA hardware schedules should be a major basis for EPA schedules.

Principal Findings

We examined the schedules for development, demonstration, and commercialization of ERDA technologies in terms of the general status of related environmental research. We have several concerns:

- o Environmental research is not systematically linked to schedules for technology research, development, and demonstration, and no procedures have been instituted to ensure that environmental information is available when it is needed for key decisions. Procedures have been proposed to improve this situation.
- o The necessary environmental information for standard setting and other decisions on commercialization of coal-based synthetic fuels probably will not be available by the mid-1980's.
- o In the pivotal area of process characterization, research in the early and middle stages of development has been inadequate to identify potentially harmful substances associated with developing coal-based technologies. Recently initiated efforts could lead to a program to achieve this result. There is an equally critical timing problem with health effects research.
- o EPA's programs to establish environmental standards are tied to the commercialization schedules only in the near term.

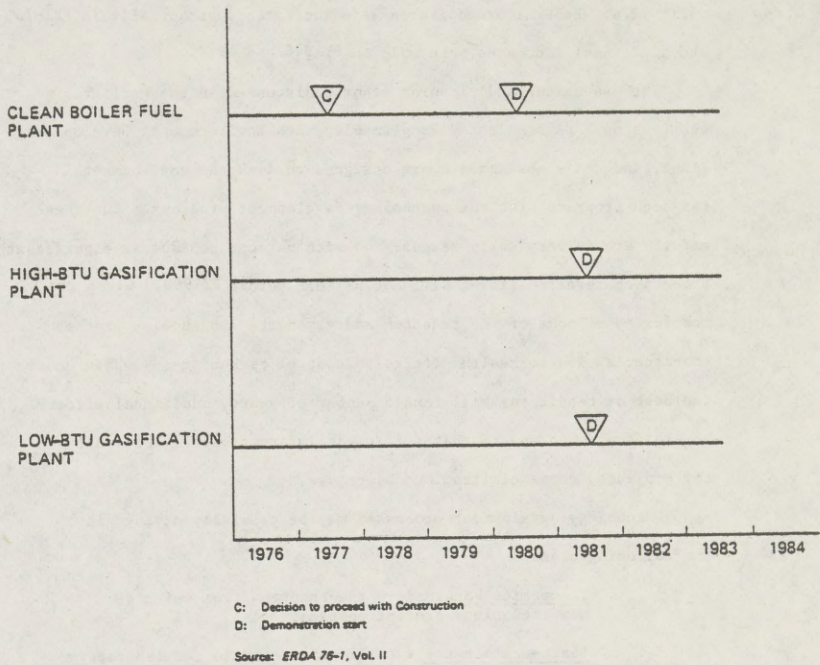
These inadequacies result in part from the fact that, at least for coal-based technologies, the federal environmental research effort is barely underway, whereas some hardware research has been in progress for many years. Consequently, ERDA must carefully reevaluate its schedules for all nonnuclear energy technologies -- near -, mid-, and long-term -- to ensure availability of adequate environmental information for informed decisions on commercialization, environmental standards, control technologies and other mitigating measures.

Phasing the Research Programs

Bringing environmental research into phase with demonstration and commercialization of new energy technologies may be the most difficult environmental task facing the R&D agencies. This problem is evident in the coal RD&D program. Figure 12 summarizes ERDA's projected schedule

Figure 12

Coal Demonstration Schedules



for decisions on demonstration and commercialization of three promising technologies. Their success could lead to efforts to commercialize some coal-synthetic processes by the mid-1980's. Some have been under active research by the federal government since the early 1960's, and almost all are at least in the pilot plant stage.

In contrast, efforts to develop a federal environmental research program related to new nonnuclear energy technologies did not begin until 1974. Federal expenditures were increased substantially in FY1975, and additional increases were made in FY1976 and 1977.

The assessment and planning efforts discussed in the earlier sections on ERDA's Balanced Program Plan, its Environmental Development Plans, and EPA's assessments are designed to link the environmental research programs with the technology development programs. But these efforts are in very early stages, and with current schedules, significant effects on research timing will not be felt before FY1980. Given the complexity of some of the research and given the sequence -- process characterization to health effects to control technology -- which under the best of conditions will take a number of years, additional efforts should be made to ensure that sufficient information will be available for projected commercialization objectives.

Technology development processes may be generally divided into the following phases:

- o Theoretical analysis - the thinking from which a new technology concept emerges.
- o Bench-scale tests - small units used in the laboratory to generate initial feasibility data for a basic technical approach. Generally only a single step in a process is tested.

- o Process development units - large units used in the laboratory to determine the reproducibility of process data, to generate information for the next stage, and to identify equipment problems. Generally only a single process step is tested, as in a bench-scale unit.
- o Pilot plants - larger units used to provide evidence that a process will work at full scale. Generally, only the steps of a process that need to be proved are piloted. The end product is not necessarily the commercial end product, nor are the effluents necessarily identical to those in the commercial process. However, similarities between the pilot plant and larger units are often substantial.
- o Demonstrations - even larger units used to produce sufficient quantities of products to prove the technical and economic viability of a process. All steps are included.

Process Characterization

This effort should begin with the bench-scale step, when products may be analyzed to provide a qualitative guide to potential environmental problems. Although the utility of this analysis is limited -- bench-scale units cannot provide data concerning the fate of residuals that would be further processed in a full-scale plant -- the qualitative information provided early will guide more refined efforts later in the development process.

At the process development unit step, residual characterization beyond that done at the bench-scale step is possible within the limitations imposed by the configuration of a particular process.

More can and should be done at the pilot plant stage because conditions begin to approximate those of a full-scale plant. The product and byproduct streams can be characterized in more detail and with more realistic expectations. There are limitations. Some of the steps that would affect the residual stream are not always included in a pilot plant, and differences in process conditions may affect residuals.

Even with these limitations, the pilot plant provides a significant opportunity for detailed characterization. Information that it generates can provide a basis for deciding whether and how to build demonstration facilities. Because the demonstration decision involves a narrowing of technology choices, it should be made with a full understanding of relevant environmental information. If characterization has not been vigorously pursued earlier in the development process, this information may not be available.

To ensure that the demonstration choice is made with the best information possible, characterization of pollutants, definition of effects, and development of control technology must all be in process during pilot plant testing. They cannot be ignored until the demonstration stage on the grounds that only technical feasibility matters up to that point.

Assessments of environmental effects associated with developing technologies are particularly important when efforts to commercialize a technology begin. Then decisions on environmental standards must be made. Demonstration-scale facilities provide the basis for comprehensive assessment of the impact of commercialization. All products and wastes may be examined and control technology approaches tested under full operating conditions.

Characterization and Effects Research

Characterization and research on effects should proceed in tandem throughout the development process, the results of one serving as a guide to where attention should be focused in the other. For example, the discovery of toxic effects of a substance indicates a need to determine whether that substance is present in a technology process stream.

Conversely, the presence of a substance that is not normally found in the human environment indicates a need to determine whether it is toxic.

Determining toxicity is not any easy task, because the structure of a chemical compound rather than simply the class of chemicals of which it is a part must be studied. The carcinogenicity of nickel compounds illustrates this point. Nickel sulfide appears to have little or no cancer-producing properties. On the other hand, nickel subsulfide produced tumors in about 8 out of 10 laboratory animals that had been exposed. Clearly, broad screening for nickel compounds would not provide conclusive evidence about the toxicity of a residual stream.

Mitigating Technology

As soon as possible problems have been identified, development of mitigating measures should begin. It could be as early as the pilot plant and must be an integral part of the demonstration facility. When problems have not been solved early, commercialization may be delayed because of regulatory uncertainty and consequent economic uncertainty, or it may be too late for process changes and only more costly retrofit solutions would be possible.

The Present Program

To determine how environmental research is related to the stages of hardware development, we examined selected program and planning elements.

Characterization at the Pilot Plant

Process characterization is pivotal in the timing of other environmental research.

Table 18 summarizes the status of characterization for the principal coal technologies supported by federal R&D. With the exception of the

Table 18		
STATUS OF COAL TECHNOLOGY ENVIRONMENTAL CHARACTERIZATION		
TECHNOLOGY	NOMINAL DEVELOPMENT STAGE	STATUS
Fluidized bed combustion	Pilot Plants	Sulfur, nitrogen oxide well-characterized; particulate data also available
Gasification		
- Synthane	Pilot Plant	Sulfur, organic and trace elements in product gas, char and ash residue, aqueous condensate, tar well-characterized
- U-gas	Process Development Unit	No information available
- HYGAS	Pilot Plant	No information available
- Bi-gas	Pilot Plant	Limited data available on H ₂ S and NH ₃ content of reactor gas; no data on metals or organics available
- CO ₂ acceptor	Pilot Plant	Some data available on sulfur, particulate, trace metals in product gas; no data on organics available
Liquefaction		
- Coed	Pilot Plant	Crude data available on sulfur, suspended solids, oil, phenols in aqueous condensate from quencher scrubber; data available on major components of product char; liquid fuel product not analyzed, although SO ₂ , NO _x , CO and HC from boiler using fuel have been measured.
- CSF (Consol)		Some data available on sulfur, NO _x , particulate, and trace metals

Synthane gasification process, detailed characterization information is limited or is nonexistent. Focus is primarily on regulated pollutants.

As a result, little is known about what substances are present and in what quantities in the product and byproduct streams of developing coal technologies -- despite the fact that they are generally in the pilot plant stage where significant characterization work is possible. Although pilot plants are not uniformly designed for characterizing pollutants and to date evaluation has depended upon the interests of researchers in the national laboratories, several of the technologies are approaching demonstration without a full effort to characterize their products and byproducts.

ERDA's Office of Fossil Energy is sponsoring research which could result in a more uniform, comprehensive approach to process characterization. The program could be operational by 1977; some results would then be available by 1979.

All process characterization work needs to be organized and coordinated to ensure the generation and sharing of necessary data. This should involve the technology development programs, environmental researchers, and those responsible for regulatory standards.

Types of Health Effects Research

Analysis of health effects is a vital component of the environmental research. Information on the health effects of chemicals that may be a part of the residuals is limited, however, and obtaining data is very difficult, time-consuming, and costly. It is needed on the toxicologic, carcinogenic, mutagenic, and teratogenic activity of these compounds.

Human Experience. Experience with humans, of course, is the best basis for quantifying health risks. The most valuable studies

generally involve exposed workers because the workplace is usually that part of the human environment where chemical exposures are most severe and because these studies often give the first indications of more general environmental problems.

When exposures can be identified and the effects are immediate, it is possible to estimate relationships between dose and effect. Effects of chronic exposure, which may be delayed or become evident only after a long time, are often very difficult to detect, however, even if the effect is severe. One reason is the extreme mobility of our society -- changing jobs, homes, and location. It tends to disperse individuals who collectively may show a major effect. Further, it is often difficult to isolate or even to recall exposures from years or decades earlier. Other reasons for difficulty in measuring the effects are a wide variety of low-level sources of exposure, different susceptibilities of exposed individuals and groups, and similar responses to exposure to other pollutants.

Studies on humans are generally costly and lengthy, and they involve following many individuals exposed to the study chemical. For new chemicals there may be no previous human experience to use as a guide. Thus, even though epidemiological studies are valuable to verify toxicological findings they have extremely limited utility for current decisionmaking. Detailed information on human health effects will not be available in the next 10 years when many of the critical decisions on coal conversion technologies are likely to be made.

Laboratory Studies. Toxicological studies conducted in the laboratory will be used to substitute for the lack of experience with humans. Traditionally, in these studies animals are exposed to fixed

levels of a chemical. Because of relatively short lifespans, rapid metabolism, and differences in metabolic pathways, physiology, and anatomy, animals develop adverse health effects more quickly than people. But even with rodents, the most convenient test animals, experiments may take 2 or 3 years or more. Moreover, with our limited understanding of the exact relationship between human and test animal metabolism, the results of such studies may be more qualitative than quantitative.

Promising new toxicological screening methods under development would cost a few thousand dollars per substance, perhaps less, and would take a few days or weeks, rather than years. With these techniques a chemical is tested on cells grown in the laboratory. If proved useful, these techniques too will yield qualitative but probably less quantitative results. There is still a need to validate the test data to provide more quantitative estimates of human hazards.

Residuals from coal processing and use are inorganic and organic mixtures whose effects may be interdependent, a factor that further complicates health effects assessment. Different processes result in different chemicals and different mixes of residual chemicals. A more systematic approach is needed for characterizing them.

To improve our ability to assess health risks from coal technologies, several important research goals must be met:

- o Development of additional rapid, inexpensive toxicological screening methods
- o Better understanding of the precise relationship between laboratory animal metabolism or cell cultures and human experience to allow quantitative estimates of health risks
- o Better epidemiological studies through improved capability to isolate and identify past and present exposures to chemicals

Unless these needs are met, research on health effects probably cannot keep pace with developing coal technologies.

A substantial health effects research program has been instituted at ERDA, EPA, and the National Cancer Institute. In one project, ERDA is testing samples collected from coal pilot plants for potential carcinogenicity. OES is also working to improve analytical techniques for more rapid measurement of hazardous substances. But given the development pace of coal technologies, needed health effects information may not be available in time for the expected demonstration projects and eventual commercialization. As mentioned earlier, coordination is needed to avoid gaps and overlaps in the research.

Setting Schedules

ERDA has set hardware schedules without regard to whether environmental research can or will be sufficiently advanced to inform technology decisions. None of the agency's current planning documents (the National Plan, the Program Approval Documents) demonstrates an explicit link between environmental research and hardware development schedules. Nor has there been a systematic examination of the need either to speed up environmental research or to adjust hardware development milestones accordingly.

ERDA's proposed environmental planning procedures, when implemented, will be designed to correct this problem. As discussed in Chapter VI, the Balanced Program Plan will attempt to tie the research and hardware schedules; the Environmental Development Plans will explicitly address the problem.

ERDA's hardware development is also not adequately linked with EPA's standard-setting activities. This separation is most evident in timing the Manuals of Control Technology Practice. For example, although the

Synthetic Fuels Manual is scheduled for 1978, at least three synthetic fuels demonstrations will be well into the design and perhaps construction stage by then.

A priority effort is needed. Part of the solution may be program coordination. Quite simply individuals responsible for research must be involved in each others' planning efforts. A central coordinating point should be designated to review the plans for technology development and environmental research to ascertain difficulties in scheduling and to make sure schedules are adjusted accordingly.

Chapter VIII

CONSIDERING ENVIRONMENT IN DECISIONS

Identifying environmental concerns throughout the planning process and addressing problems through timely environmental research provide the foundation for adequately building environment into RD&D programs. The process is complete when the information is fully weighed in technology development decisions at all important levels:

- o The National Plan should consider the environmental aspects of competing technologies and should discuss them explicitly.
- o Program planning leading to choices among technological options should be based on the best available environmental information presented in a program impact statement. There should be uniform guidelines for preparation of environmental impact statements for all nonnuclear energy RD&D programs. Program impact statements should be prepared prior to commitment to demonstrate a technology.
- o Individual project decisions should fully reflect the environmental aspects of construction and operation through environmental assessments and, where appropriate, environmental impact statements.

Planning for energy RD&D and making key decisions are complex tasks. They require facts and judgments from a wide variety of sources and indeed benefit from a healthy competition of ideas. The social welfare objectives which must be considered, particularly those related to the environment, require that single-party decisions be avoided and that procedures be established for adequate checks and balances.

The concept of checks and balances incorporates elements normally found in the activities of a large federal agency. With its hierarchy of decisionmakers, the agency management structure provides a check on decisions made at lower levels. More broadly, there are built-in checks on policy issues through the Executive Office of the President

and through the Congress on all oversight and appropriation processes. At all these levels, agency decisions may be changed, policies reexamined, and priorities reevaluated.

These activities are part of the normal workings of the federal government and are not unique to a particular agency. But in addition, the programs of individual agencies call for checks and balances of a different order. Needed for consideration of the environment in the energy research and development programs are the following:

- o Oversight and checkpoints within ERDA to ensure that environment is being adequately considered
- o Participation within ERDA of a variety of disciplines in developing agency programs and plans
- o Provision for public review of all proposed major agency planning and decisionmaking
- o Establishment of consistent standards of environmental adequacy for key program decisions.

Principal Findings

Decisionmaking within ERDA is improving, but there are significant problems related to the environment:

- o The National Plan was developed with only superficial consideration of the environmental effects of its alternative planning futures and did not discuss the environmental consequences of the technologies proposed for priority attention. The review process for the National Plan is good, but environmental information is lacking.
- o ERDA has committed itself to using environmental impact statements as major decision documents. This commitment is highly desirable but is not yet backed by uniform guidelines and procedures directed explicitly at the problems of nonnuclear RD&D.
- o Some programs are progressing in developing impact statements. However, at the program level, commitments to demonstration of technologies have been made without sufficient consideration of environmental impacts.

- o Environmental considerations are not yet being adequately factored into individual project decisions. There has been no public or general agency review of program or project decisions through the NEPA process or by other means.
- o Procedures are evolving which could provide the basis for internal environmental checks on the planning and decisionmaking of the technology programs. They are not yet functioning, and decisions are being made with insufficient review.

We believe that well-defined procedures for preparation of environmental assessments and impact statements and for consideration of environmental information in decisions will result in more environmentally sound technologies.

It is true that energy RD&D program decisions are only as good as the information which supports them and that an adequate information base takes time to develop. ERDA should increase the flow of this information into decisionmaking as rapidly as possible. Proposed environmental impact statement procedures and the environmental development plans discussed in Chapter VI should aid this process. In their absence, ERDA should take great care not to make decisions which irrevocably commit to a course of action. Procedures must be formalized for periodically reevaluating all significant commitments based on new information.

The National Plan for Energy RD&D

Decisions vary greatly at different levels, but each one represents some focusing of effort and some narrowing of choices. At the level of the National Plan, broad strategic policy options are considered. The Federal Nonnuclear Energy Research and Development Act directs ERDA "to evaluate the economic, environmental and technological merits of each aspect of the program" in formulating the plan. This charge means

evaluating planning alternatives (i.e., alternative "energy futures") and setting priorities in terms of their environmental effects just as fully as energy, economic, and other effects are evaluated. In addition, it means that ERDA is to analyze and compare the environmental and social consequences of the proposed technologies.

The Current Plan

Energy RD&D priorities in the National Plan reflect only the most rudimentary consideration of the environmental implications of proceeding with the technologies enumerated. ERDA 76-1 makes clear the fact that the analysis linking goals and priorities was very limited and that the agency has just begun to analyze energy, economic, and environmental tradeoffs.

It states that "environmental information with the required degree of precision is not currently available" and presents the results of its analyses only in terms of energy and economic factors. Until substantial improvement is made, particularly in the environmental analysis used in formulating program priorities, the National Plan will not reflect the broad perspective that the Congress mandated and that ERDA is committed to maintain.

ERDA's Reference Energy System quantifies many of the known residuals and allows comparisons of the environmental aspects of alternative energy systems. In addition to RES, ERDA should develop a framework for examining and presenting the environmental uncertainties associated with the energy systems. Then the technologies competing for priority in the National Plan could be roughly compared and ranked in a systems context. Comparisons will become more sophisticated as better environmental information is developed by the research programs.

Review of the Plan

Both ERDA-48 and ERDA 76-1, the first two versions of the National Plan, were reviewed within and outside ERDA. The Office of Environment and Safety, however, played only a limited role in their preparation.

The public has had an opportunity to comment in a well-conceived series of regional public meetings (Atlanta, Seattle, Denver, and Chicago). CEQ also held public hearings (see Appendix A). The congressional Office of Technology Assessment also reviewed the reports. ERDA's revised priorities reflect comments on the plan.

Although as ERDA 76-1 states, "no one document can cover all areas that make up the complex energy RD&D spectrum," the environmental issues raised in this report are vital, and they must be addressed in future versions of the National Plan. If they are not, environmental review and comment will be inadequate.

Program-Level Decisions

Choices at the program level are more explicit than at the national level. For example, selection among alternative coal-using technologies for development and demonstration commitments should be based on evaluation of all reasonable options. In deciding which technologies to demonstrate, ERDA must give high priority to environmental acceptability, technical feasibility, and economics.

Use of Impact Statements

Program environmental impact statements should be the key means to adequate consideration of the environment. A program impact statement which carefully examines the drawbacks and the benefits of a range of choices is an important aid in deciding on the technology or technologies

to demonstrate. The National Environmental Policy Act requires that detailed EISs be prepared on recommendations or reports on proposals for major federal actions significantly affecting the quality of the human environment. This requirement pertains to proposals for program actions as well as to proposals for individual projects. Technical research and development programs specifically require impact statements.*

Statements should be prepared early enough in the development process that the information is useful in decisionmaking, but it should be prepared late enough to contain meaningful information -- that is, before RD&D activities have reached a stage of commitment to implementation likely to determine subsequent development or to restrict later alternatives. When deciding whether to build pilot plants, there may not be enough information to do a program EIS (although a pilot facility may require a site-specific EIS). But program evaluation should certainly occur prior to the decision to build demonstration plants. Broad program statements should be prepared prior to decisions committing ERDA to demonstration of a specific new technology.

Procedures

ERDA is presently making commitments to the demonstration of many technologies. They span virtually all the program areas: fossil fuel, solar, geothermal, and energy conservation. Some are nearing or are entering the construction phase; others are being planned. But ERDA

* See Scientist's Institute for Public Information v. Atomic Energy Commission, 481 F.2d 1079 (D.C. Cir., 1973), requiring preparation of a program statement prior to the decision to proceed with demonstration of the liquid metal fast breeder reactor.

has no process for fully considering environmental factors in making program choices.

As of May 1976, one program impact statement had been filed with CEQ.* In the coal program, three demonstration projects are underway, two are in the proposal phase, and one is in the design phase. A program EIS for coal technologies is being prepared.

The process now being followed for coordinating preparation of the coal program EIS shows promise as a model for future statements. The Office of Fossil Energy, in addition to using its own expertise and contractor assistance, is requesting the assistance of experts in other parts of ERDA and federal agencies. The Office of Environment and Safety is now helping. Existing EIS procedures call for final review and approval of the draft EIS by OES before it is made public, a necessary check which should be retained.

No impact statements are being prepared for other nonnuclear program areas, although assessments are being prepared. The Council could find no other vehicle for providing environmental information needed for program choices -- or for outside review by other federal agencies or the public. A serious gap exists in adequately considering environment in developing technology RD&D programs.

Part of this problem can be attributed to agencywide procedures for complying with the environmental impact statement requirements of NEPA. ERDA is using procedures developed for the nuclear programs of the Atomic Energy Commission and has not adjusted them to reflect the widely divergent

* Draft environmental impact statement on the Proposed Synthetic Fuels Commercialization Program.

nonnuclear RD&D. In the nonnuclear programs, hundreds of smaller-scale demonstration projects may be carried out in the solar energy program alone, for example. The environmental effects and the sequence of planning and decisionmaking vary greatly from program to program.

The timing and preparation of impact statements will require careful interaction of the NEPA procedures with the Environmental Development Plans. When this report went to print, procedures had not been published.

ERDA 76-1 commits the agency to using the impact statement as a major input to decisionmaking. The Office of NEPA Coordination has responsibility for developing guidelines and providing counsel to ERDA program offices responsible for EIS preparation. The office reports directly to the Assistant Administrator for Environment and Safety.

A promising precedent for program environmental impact statements was set by the proposed Synthetic Fuels Commercialization Program. It was developed under an interagency task force in which ERDA participated. The environmental evaluation which culminated in preparation of an impact statement began when the program began and culminated in development of an environmental protection strategy which will guide projects receiving federal assistance under the program.

ERDA's handling of the liquid metal fast breeder reactor was a sensible procedural approach to the environmental uncertainties of a new energy technology. After considering the final detailed program EIS, the Administrator decided to proceed with the LMFBR demonstration program but stated that the many environmental uncertainties can be resolved only by further research and demonstration. To remedy this, he committed the agency to subsequent environmental reevaluation in the mid-1980's through preparation of another program impact statement.

Individual Project Decisions

Demonstration facilities usually require preparation of a full environmental impact statement. Analysis at the project level concerns such issues as the environmental impacts of construction and operation of a proposed facility, alternative sites, and ways of lessening effects of plant construction and operation.

Individual project decisions can range from those which are relatively simple, such as installation of solar heating devices on buildings, to those which cause a variety of environmental impacts, such as demonstration of large synthetic fuel plants. The levels of information required for environmentally informed project decisions, then, may vary widely.

For the more complex demonstration projects in the coal synthetics area, there is no single "decision." Rather, a sequence of decisions begins when the Office of Fossil Fuel Research requests proposals. The number of potential contractors is narrowed and preliminary design activities commence. The process ends with selection of a contractor, selection of a site, and the final decision to proceed with construction of a plant.

The Coalcon Clean Fuels Project is the only coal-synthetics demonstration facility which has proceeded beyond the preliminary stages. An environmental impact statement being prepared for this project should be available in time to guide the final decision on construction of the plant. However, although environmental information was incorporated in the site selection process, earlier decisions on the project, such as selection of the process, contractor, and site for the facility, were made without an impact statement. ERDA plans to prepare EIS's for future demonstration projects earlier in the process.

ERDA's procedures should carefully address the timing of environmental impact statements for all technology programs. Measures should be taken immediately to

identify the program and project impact statements likely to be required, and preparation should begin as soon as possible to provide input into the decisions that will be made.

APPENDIX A

SUMMARY OF CEQ PUBLIC HEARINGS

As part of its ongoing assessment under the Nonnuclear Energy Research and Development Act, the Council was directed to hold annual public hearings on environmental and energy conservation RD&D issues. They were held in September 1975 in three cities. Washington, D.C. was selected in order to hear the views of national organizations. Regional interest in new forms of energy technology (particularly solar and geothermal) and transportation-related energy issues led to selection of Los Angeles and Detroit.

The Council actively solicited participation of a wide range of potential participants. Witnesses included industry groups, environmental and public interest groups, state and local government officials, independent researchers and scientists, organized labor, and individual citizens.

Testimony was presented before a panel chaired by the CEQ. Additional panel members were distinguished educators, scientists, and government officials.

A principal focus of the hearings was ERDA's National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future (ERDA-48).

Although the hearings were directed at the environmental effects and conservation aspects of nonnuclear energy RD&D programs, much of the testimony addressed other aspects of the National Plan, its goals, methodology and assumptions, and priorities assigned to alternative supply technologies.

The testimony often reflected confusion about ERDA's responsibilities in the national energy program. Suggestions were offered regarding programs which may fall within the purview of the Federal Energy Administration, the Environmental Protection Agency, the Department of Housing and Urban Development, and the Department of Transportation.

ERDA's National Plan was acknowledged by panel members and many witnesses as a step forward in facing this country's energy problems, and a number of witnesses began their statements by expressing satisfaction with the overall program. But the witnesses were responding to a call for public evaluation of federal nonnuclear energy RD&D, especially from the viewpoint of energy conservation and environmental protection, and most of the testimony centered on these areas and others of special concern to the witnesses.

This summary covers the major recurrent issues, identified by how often they were mentioned in the testimony (see Table A-1). The first part of the summary regards issues in general; the second pertains to interest groups.

Conclusive inferences should not be drawn. Failure of an interest group representative even to mention a particular ERDA program indicates little about the group's interest in or satisfaction with that program. Absence of comment may simply suggest a more pressing interest.

Because of these difficulties of interpretation, the approach taken both in this summary and in the published hearings review* is descriptive of attention to major recurrent issues.

General Issues

Conservation. About two-thirds of the 90 witnesses addressed ERDA's approach to conservation and the relative priority assigned to RD&D programs in this area. Over one-half of all witnesses indicated that the National Plan was deficient in attention to energy conservation-- the 1.3 percent for conservation RD&D in the FY 1976 proposed budget was evidence of its low priority. Many of the witnesses felt there was undue emphasis on increasing energy supplies

*Council on Environmental Quality, Report on 1975 Public Hearings.

Table A-1
SUMMARY OF MAJOR ISSUES: FREQUENCY OF OCCURRENCE BY INTEREST GROUP

	Industry (N=27)	Public Int./Env. (N=28)	Researchers/ Scientists (N=13)	State/Local Gov't. (N=12)	Indiv. Citizens (N=9)	Labor (N=1)	Other (N=1)	Total (N=91)
<u>Conservation-Related Issues</u>								
-Increased Emphasis on Conservation	4 (15%)	15 (54%)	3 (23%)	9 (75%)	5 (56%)	1	-	37 (41%)
-Suggested Areas for Conservation R&D	17 (62%)	15 (54%)	4 (31%)	6 (50%)	4 (44%)	1	-	47 (52%)
<u>Issues Related to Environmental, Social, Economic, Health and Safety Effects of Nuclear Energy Technologies</u>								
-Increased Attention to Environmental Protection	3 (11%)	8 (29%)	2 (15%)	3 (25%)	2 (22%)	1	-	19 (21%)
-Need for Regional and Local Considerations	4 (15%)	6 (21%)	4 (31%)	4 (33%)	-	1	1	20 (22%)
-Need for R&D on Environmental Controls & Impacts, Fossil Fuel Development	10 (37%)	8 (29%)	1 (8%)	3 (25%)	-	-	-	22 (24%)
<u>Changes in Plan Methodology</u>								144
Increased Public Participation in Energy Planning and Policy Making	8 (30%)	11 (39%)	3 (23%)	3 (25%)	2 (22%)	-	1	34 (37%)
Increased Emphasis on Solar Energy R&D	1 (4%)	14 (50%)	2 (15%)	7 (58%)	4 (44%)	1	1	26 (29%)

**** Table 1 shows the major recurrent issues and the number of statements (N) in which those issues appear. Percentages in each column indicate the proportion of statements made within each interest group. For example, 15 percent of all statements made by industry representatives call for a greater emphasis on conservation.

NOTE: Care should be taken in drawing inferences from the data. No attempt was made to quantify statements of general satisfaction with the overall plan or the scattered expressions of agreement with specific programs.

and too little on reducing energy demand. Witnesses emphasized the significant contribution of conservation in the near term until environmentally acceptable technologies are developed, and they also noted its continued importance in the longer term.

RD&D in the area of "soft technologies," which might facilitate reduced consumption levels, was suggested -- on peak load electrical pricing, metering technology, development of building standards, and development of product life-cycle cost information for consumers, for example. Development of technology transfer mechanisms which would enable users (particularly state and local governments) to implement existing technology was also suggested. More specific suggestions for the conservation program were regulations and incentives to encourage the development or use of more energy-efficient products and systems, including tax credits for investors and surcharges on energy usage over a base amount.

Several witnesses argued that ERDA failed to consider market forces in determining both consumption patterns and technology development and that oil and gas could be conserved and more efficient systems introduced through higher prices.

Witnesses saw a need for a broad public education program to inform energy consumers about reducing consumption. Product labeling information and conservation RD&D findings were suggested measures.

The effects of energy conservation on economic productivity and employment were widely debated, and additional research focused on analysis of the social and economic impacts of reduced consumption was suggested.

Conservation RD&D felt to be deserving of more attention or higher priority were end use efficiency, particularly heat pump technology, and electrical production efficiency, particularly fuel cell technology. Advocates of accelerated transportation conservation technology called for additional funding for development of alternative engines and alternative automotive fuel sources. More emphasis on mass transportation systems was also recommended.

Environmental and Other Effects

Attention to environmental protection was found lacking by approximately one-fifth of all witnesses. Many felt that ERDA's assessment of energy technologies had not given due importance to environmental and social acceptability as criteria. Their view was that if environmental considerations had been given comparable weight to cost and time factors, priorities would be different.

It seemed to some that energy production had been given much greater consideration than the protection of health, safety, welfare, and the environment in ERDA's national energy RD&D goals. Several witnesses judged inadequate the low percentage of ERDA's proposed budget for environmental and safety research.

Witnesses urged that environmental assessment and control be made an integral part of the development of new technologies in order to avoid major costs and conflicts after substantial investments are made. They called for greater emphasis on developing control technology in advance of implementation of oil shale and coal liquefaction technology, for example.

Witnesses also cited the general need for RD&D in reliable pollution control technology, particularly for sulfur compounds, nitrogen compounds, and fine particulate emissions.

Participants asked that these and other costs of environmental protection be fully reflected in energy prices to allow the public to make informed market choices. They also recommended cost-benefit analyses of environmental control measures in order to avoid unnecessarily stringent environmental controls.

Witnesses suggested that the social, economic, and environmental impacts of alternative technologies should be compared and capital requirements considered. Absence of criteria for measuring local and regional impacts of energy technologies was noted by approximately one-fifth of all witnesses.

Regional differences in weather patterns, land use, and water supplies were all considered to warrant particular examination. For example, it was pointed out that although ERDA recognized constraints of water availability, the figures used were based on national averages and did not account for special problems encountered in the arid southwest and Rocky Mountain states.

Availability of water makes the Great Lakes area attractive for energy production. Concerns there centered on potential problems of powerplant siting and conflicts about interbasin transfers.

ERDA was asked to study the impacts of shifts in energy production bases caused by the development of new technologies. Suggested areas of study included the effects of diverting land from agriculture and recreational purposes, the impact of population influxes on the demand for public services, and potential disruption of local economies.

Planning Methodology

Over one-third of all witnesses noted shortcomings in the methodology employed by ERDA in the development of its plan. Several believed that ERDA should have used net energy analysis to compare relative energy savings,

environmental impacts, and capital requirements. The absence of cost-to-completion estimates or cost-benefit analyses of the alternative technologies proposed for development was also criticized.

Scenario O, No New Initiatives, was criticized for the employment of an annual growth rate of 3.5 percent until 1985 and to 3 percent thereafter. Critics claimed that this growth rate was overstated and at variance with the 2.8 percent growth rate (\$11 per barrel oil) projected by the Project Independence report. Also noted was the omission or underestimation of the effects of conservation in ERDA's scenario development. Citing previous research and their own experiences, witnesses argued that conservation could play a larger part in meeting energy needs than was apparent in ERDA's projections.

Some witnesses felt that the plan demonstrated a pronuclear bias in ERDA's Scenario IV, the Limited Nuclear Power Scenario. In their view, ERDA's dismissal of this scenario as unacceptable was brought about in part by an underestimation of the effects of conservation.

Goals and Criteria

Several witnesses objected to ERDA's goal of expanding the domestic supply of energy, pointing out that it may in fact be more desirable to import energy for as long as possible while preserving domestic resources. Witnesses argued that full-scale development is not the only means to ensure national security; stockpiling is an alternative. Alternative energy development may require imports of raw materials, and, in the interest of national security, planning should include monitoring the availability of raw materials.

Noting that ERDA had based the acceptability of scenarios on associated levels of imports, witnesses urged that broader considerations, such as impacts on health, the environment, and the economy, be used in evaluation.

Also questioned was ERDA's goal of ensuring that future life-style options not be limited by energy availability. Some stated that life styles are already changing because of recent changes in energy price and availability. Several witnesses warned that exponential growth could not continue indefinitely and that the public must learn to change its wasteful habits.

Projections of energy yield were disputed. Advocates of accelerated solar and geothermal development noted that ERDA's projections for these sources were considerably lower than estimates in other reports, most notably the NSF-NASA Solar Energy Panel Report and the Hickel Report on geothermal energy.

ERDA's projections of up to 2.5 quads (10^{15} Btu) of energy from waste materials by 1985 was viewed as unrealistic because, it was contended, such an output would require the conversion of the entire waste stream of the nation.

Future planning efforts should include a wider range of energy strategies than those considered in the six scenarios offered. Further, ERDA's timetable for technological development and the scenarios associated with the timetable allowed too little room for error, and witnesses asked that future planning efforts make clear the comparative risks of failure of various alternatives.

Witnesses urged that planning continually review the results of ERDA's projects, with an eye toward the actual energy savings-per-dollar investment. Reporting of failures was also encouraged.

Public Participation

The desire to achieve greater coordination and input into federal energy planning and policymaking was expressed by approximately one-third of all witnesses, although it was recognized that the Council's hearings were a step in this direction.

Industry representatives noted that private sector RD&D efforts were longstanding and that their expertise was a valuable resource available to

the federal government. State and local government officials called for greater coordination among all levels of government, especially because programs are implemented and resource allocation decisions made at the local level.

Individual citizens and public interest and environmental groups questioned ERDA's commitment to public participation in its planning process; the plan did not specifically include citizen groups in its section on the private sector.

A coordinating committee established through the National Governors' Conference to ensure public participation in future planning was suggested. Industry representatives suggested advisory committees to participate in planning sessions with ERDA. Some citizens criticized public hearings as inadequate to reach the many people who should be involved, and one person suggested town meetings.

Solar Energy

Following in frequency of expressed concerns was a call for additional emphasis on the accelerated development of solar energy. It was suggested that incentives for use of solar heating and cooling should be instituted. More widespread demonstration of solar energy would accommodate differences in regional and local conditions.

Often pointed out in support of solar energy (including solar heating and cooling, solar electricity, fuels from solid waste and biomass, wind energy, and ocean thermal gradients) were the relatively few adverse environmental impacts associated with its use. Other encouraged use of solar energy to conserve scarce nonrenewable resources. To many it is an attractive alternative to nuclear energy.

Other Issues

Of concern to several witnesses, notably environmental groups and the gas industry, was ERDA's vision of an increasing reliance on electrification

to meet national energy needs. These witnesses contended that electrical generation is more energy intensive than alternative uses of fuels for direct heating and cooling. They therefore recommended development of industrial total-energy systems, using waste heat, and an increased emphasis on the role of natural and synthetic gas as more energy- and capital-efficient alternatives.

Several witnesses objected to ERDA's apparent emphasis on large-scale, centralized energy systems. They claimed that it would be inefficient to use large-scale sources for small-scale electrical uses, and suggested a reexamination of the economies of scale of electrical generating units, particularly for various types of solar energy systems.

Interest Group Concerns

Industry

Several issues dealt with private industry and government relationships. Nearly half of all industry groups represented indicated that institutional barriers to the development of new technologies were hampering private efforts and called for the revamping of unnecessary and poorly coordinated regulatory and reporting requirements.

Among other concerns were the need for federal RD&D policies which, recognizing industry's profit incentives, make reasonable contractual arrangements and allow industry to maintain patent rights, and the need for coordinating mechanisms to encourage adoption of new energy technologies and to improve the effectiveness of existing systems.

Also of concern was the cost of environmental control. Approximately one-fourth of industry witnesses asked for studies of the relative costs and benefits of technology implementation in order to avoid unnecessary controls.

State and Local Government

Conservation was the greatest concern to state and local government officials, three-fourths of whom called for more emphasis in the ERDA program. They cited success of local and statewide conservation programs in reducing demand levels and added that there was still considerable room for improvement.

Noting that energy problems at the state and local levels require immediate solution, they urged that mechanisms be developed to transfer existing technologies to the state and local levels where services are delivered. The translation of new technologies into building codes and land use plans and local forecasting techniques for energy demand were suggested areas for research.

Government representatives were also concerned with the need for more federally funded demonstrations, or "proof-of-concept" research, in areas where technology was already developed. For example, differences in local conditions required a series of solar energy demonstrations on a national scale.

Over one-half the state and local representatives called for accelerated solar RD&D. In particular, Californians feel that solar energy is an attractive alternative or supplement to natural gas.

Environmental and Public Interest Groups

Of greatest concern to environmental and public interest groups was a perceived lack of emphasis on conservation. Over one-half viewed conservation as an underutilized and more desirable alternative to increased supply and its associated environmental impacts.

Many witnesses, including one-half of all citizen groups testifying, prefer conservation to continued development of nuclear energy. Witnesses

claimed that nuclear power yields a small amount of energy in relation to its capital requirements, dangers of sabotage are great, the problems of radioactive waste disposal are unsolved, and the risks to public health and safety are significant.

Acceleration of solar RD&D was also called for by one-half the citizen group representatives because solar energy is more acceptable environmentally than other technologies. Additional emphasis on development of other renewable resources, including geothermal energy, was also urged.

Over one-quarter of environmental and public interest group representatives felt that the ERDA plan gave inadequate attention to environmental protection, noting that the plan seemed to focus narrowly on the technical aspects of supply technologies.

Labor

The United Auto Workers, the only labor union to submit testimony at these hearings, noted that while ERDA seemed to address three facets of the energy problems -- supply, conservation, and environmental protection -- it overlooked a fourth facet, that of social impacts. They urged that the social dislocations caused by unemployment and higher prices be identified through research in advance of their occurrence. Arrangements, such as special subsidies, to ease the burden of these dislocations on the unemployed and lower-income groups were suggested. Part of the concern about employment dislocations stemmed from an awareness that such dislocations could lead to increased resistance to necessary environmental controls. Further, ERDA's concern for effecting a smooth transition to new energy systems without disrupting existing investments was not matched by similar concern for workers or others without financial assets.

Comparisons of Issues by Interest Group

Most striking is the preponderance of conservation issues that emerged during the course of the hearings. As seen in Table A-1, however, a significant proportion of interest groups, but less than one-fourth of industry representatives, indicated insufficient emphasis on conservation in the ERDA plan. On the other hand, industry representatives most frequently offered suggestions for conservation RD&D. Although both groups agreed on the need for RD&D in end use efficiencies, industry more often called for additional RD&D in new hardware, and environmental and public interest groups called for additional research in socioeconomic effects and in implementation of existing conservation technology.

The importance of public education was repeatedly stressed by all groups. The consensus was that if the public were aware of the energy problem and were provided with the information to make intelligent choices, a conservation ethic would be successfully developed.

Environmental issues figured much less prominently than conservation. Of particular note is the fact that less than one-third of environmental public interest groups addressed the adequacy of ERDA's environmental program, compared with over one-half who addressed conservation. (Much of the support for conservation, however, was based on the reduced environmental impacts expected.)

Industry's major environmental concern was examining the costs and benefits associated with environmental protection in order to avoid unnecessary, costly, and sometimes unreliable environmental controls. Environmental and public interest groups, in contrast, asked that socioeconomic impacts be studied. Of great concern to all, was the need to consider regional and local conditions in assessing primary and secondary impacts of technology development.

Although most criticism of ERDA's plan development came from environmental-public interest groups, all groups expressed some dissatisfaction. Of concern to both industry and public interest groups was the absence of net energy analysis; industry representatives further noted the absence of cost analyses. Environmentalists took exception to use of import levels as a criterion for determining acceptability of alternate scenarios and urged that other considerations, including health, environmental, and economic effects, be used as well.

A clear division of interest emerged regarding development of nuclear and solar energy. Almost all antinuclear statements were made by environmental and other public interest group representatives, about one-half of whom took this position. Notably, one environmental group, two industry representatives, and one official supported the nuclear program. Six industry representatives urged greater emphasis on various aspects of the nuclear program, including the liquid metal fast breeder reactor.

In contrast, an accelerated solar energy program drew the support of one-half the environmental-public interest groups, over one-half the state and local government officials, and one-half the unaffiliated individuals testifying. Only one industry representative addressed this point in testimony.

Industry and environmental groups alike agreed on the increased use of coal as a direct and primary fuel. For some, increased coal usage was preferable to increased reliance on nuclear energy. Environmental groups called for land reclamation, mine safety measures, and manpower training as a part of the coal development programs.

On the issue of private versus federal roles in energy RD&D, industry views were fairly evenly divided. Several witnesses felt that ERDA should concentrate on conducting basic research and should leave demonstration

projects to private industry; others felt that more federal support was needed for high-risk programs through the demonstration and pilot stages. Citizen groups focused on the federal government as watchdog over federally sponsored research in order to protect public interests.

All groups felt that the public should participate more in energy planning and policymaking. State and local government and industry representatives, in particular, noted the need for better coordination at all levels of government.

APPENDIX B

ESTIMATES OF THE NET CONSUMER BENEFITS
OF ENERGY CONSERVATION TECHNOLOGIES

New conservation technology can reduce the amount that consumers will spend on energy. In general, however, devices which use energy more efficiently cost more initially. New technologies which reduce energy spending by more than their extra initial cost provide a net economic benefit to consumers. If total individual consumer benefits which new technology can produce over time is large, it may make sense to invest a part of this potential benefit in the private and/or public sector RD&D required to make the new technologies available. This appendix estimates the net benefit for several residential space heating and automobile energy conservation technologies.

Residential Space Heating

Three residential space heating technologies are used to illustrate an estimating technique: structural improvements which reduce heat losses (e.g., insulation), an electric heat pump, and a thermally actuated heat pump. They represent a small fraction of the residential energy conservation possible. The technique used is a simple one, glossing over many points which should be considered before resources are committed.

The approach involves three steps. First, a baseline estimate of residential space heating energy consumption and related consumer spending through the year 2020 is made assuming that technology remains static. Then each technology is factored in, one at a time. For each, the incremental purchase and installation costs and the energy savings which result are calculated for each year (installation costs and savings are in constant 1975 dollars). Last, future extra costs and savings are expressed in 1975-equivalent terms by discounting at a 7 percent rate.

Baseline estimates are derived from the number of houses expected to be heated in the future. Allowance was made for four geographical regions, three house types and sizes, and three kinds of heating systems. Future energy consumption is based on applying region and heating plant-specific structural heat loss and heating system efficiencies to the numbers, sizes, and kinds of houses forecast (see Tables B-1 through B-5).

The three technologies were applied successively to the housing stock forecast. The Structural Improvement option consisting of improved construction and insulation was applied first. This was followed by Improved Electric Heat Pumps and Thermally Actuated Heat Pumps. Each technology was introduced when it is first expected to be commercially available; after that, each gradually penetrates the housing stock over time.

Application of the technologies was translated into energy savings by multiplying the number of houses which contain them by the improvements in heat loss or heating system efficiencies which each is expected to produce. Effects on residential energy consumption are shown in Figure B-1.

Incremental consumer costs were calculated from the number of units installed over time under each option multiplied by its extra initial costs. Energy savings were calculated by multiplying the price of the energy saved by the reduced quantities shown in Figure A-1. In 1975 dollars, oil and gas were priced at \$3 per million Btu's and electricity at \$11.50 per million Btu's of electricity. These prices represent the estimated costs of energy produced by new supply technologies now being developed. Discounted to the present at 7 percent, the benefits and costs that result are shown in Table B-6.

Automobile Transportation

Auto fuel improvement technologies also were analyzed. Four are new or improved engines: a stratified charge Otto-cycle engine, a Diesel engine, a

TABLES: RESIDENTIAL SPACE HEATING ESTIMATES

B-1: HOUSING STOCK FORECAST (thousands of units)				
	<u>Single Family</u>	<u>Multiple</u>	<u>Mobile</u>	<u>Total</u>
1975 North Central	12,874	5,380	730	
Northeast	9,054	7,454	341	
South	15,495	4,553	1,358	
West	8,310	3,656	776	
TOTAL	45,733	21,043	3,205	69,981
2000 North Central	17,015	7,613	1,461	
Northeast	11,717	9,941	658	
South	22,155	7,276	3,044	
West	12,400	5,956	1,889	
TOTAL	63,287	30,786	7,052	101,125
2020 North Central	18,907	9,304	1,973	
Northeast	12,795	11,521	850	
South	25,228	10,004	4,417	
West	14,567	8,185	2,818	
TOTAL	71,497	39,014	10,058	120,569
Source: Thomas C. Marcin, <u>Projections of Demand for Housing by Type of Unit and Region</u> , U.S. Department of Agriculture, revised 1976				

B-2: LIVING SPACE (sq. ft./unit)			
	<u>Single Family</u>	<u>Multiple Family</u>	<u>Mobile</u>
North Central	old 1308	900	600
	new 1560	1000	600
Northeast	old 1353	900	600
	new 1560	1000	600
South	old 1247	900	600
	new 1560	1000	600
West	old 1372	900	600
	new 1560	1000	600
Source: Arthur D. Little, Project Independence Residential Demand Model			

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B-3: BASELINE HEAT LOSS (10^3 BTU/yr./sq. ft.)		
	<u>Gas/Oil</u>	<u>Electric</u>
North Central	76	60.8
Northeast	63.4	50.7
South	44.9	35.9
West	38.8	31
Source: Rand Corporation, <u>Energy Use and Conservation in the Residential Sector</u> (June 1975)		

B-4: THERMAL EFFICIENCIES AT SITE OF END USE				
	<u>Northeast</u>	<u>North Central</u>	<u>South</u>	<u>West</u>
Gas/Oil Furnace	.57	.57	.57	.57
Electric Baseboard Heater	1.0	1.0	1.0	1.0
Electric Heat Pump	1.8	1.7	2.0	1.7
Thermally-Actuated Heat Pump	1.0	.95	1.1	.95

B-5: UNIT COST INCREMENTS (dollars/unit)			
	<u>Single Family</u>	<u>Multiple Family</u>	<u>Mobile Home</u>
Structural Improvements *	1000	450	300
Electric Heat Pump **	1100	1100	N.A.
Thermal-Activated Heat Pump ***	1400	1400	N.A.
* Derived from: Rand Corp. <u>Energy Use & Conservation in the Residential Sector</u> , (June 1975)			
** Derived from: <u>Evaluation of Air-to-air Heat Pump for Residential Space Heating</u> , Gordian Associates, Inc. (October 1975)			
*** Source: telephone conversation with Dr. Didion, Bureau of Standards			

Figure B-1

Energy Consumption for Residential Heating

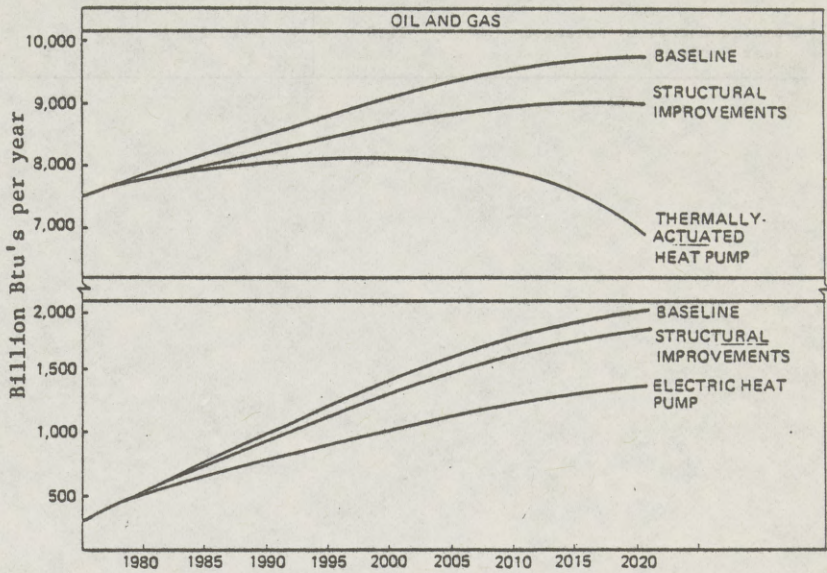


Table B-6

Estimated Net Economic Benefits
(\$ billions 1975)

	<u>Benefits from Energy Saved</u>	<u>Cost of Implementation</u>	<u>Net Benefit</u>
Structural Improvements -- Improved Construction & Insulation	\$14.7	\$11.3	\$ 3.4
Improved Electric Heat Pumps	17.3	6.4	10.9
Improved Thermally-Actuated Heat Pumps	11.8	10.2	1.6

Stirling-cycle engine, and a Brayton-cycle engine. The other is an improved drive train, body, and tires (labeled nonengine redesign). An estimating approach similar to the one applied to residential space heat technologies was used.

Baseline projections are based on size of the vehicle fleet and annual vehicle miles. Through 1985, the forecast is based on the Federal Energy Administration's Gasoline Consumption Model*; beyond 1985, fleet size is then based on Bureau of the Census demographic estimates. Mileage per vehicle is extrapolated at an historical rate of increase.

Fleet size and utilization forecasts were translated into energy consumption rate per class. Through 1985, the fleet mix is based on the FEA model; thereafter, the mix was approximately constant (see Tables B-7 through B-10).

Similar to the residential space heating example, the auto technologies were applied to the baseline forecast, beginning with the option which produced the most net benefits, nonengine redesign. (Availability of a first generation version was assumed in 1981, an advanced version in 1990.)** The availabilities of the engine options were assumed as follows: Stratified Charge (1975); Diesel (1977/1989); Stirling (1982/1989); and the Brayton-cycle Engine (1984/1990).

In contrast to residential space heating, however, the benefits estimates assume that only one of the four new engine alternatives would succeed; consequently, the effects of each engine option are compared with each other, after nonengine redesign was applied. Following initial introduction, the market penetration of the new technologies increases gradually over a 20-year period. Because only new autos are involved in improvements, they affect the average fuel economy of the

* Gasoline Consumption Model, Energy and Environmental Analysis, Inc., prepared for the Federal Energy Administration.

** Based on: Jet Propulsion Laboratory, Should We Have a New Engine? (August 1975).

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 TABLES: AUTOMOBILE FUEL ECONOMY IMPROVEMENTS

B-7: FLEET CHARACTERISTICS AND USE			
Year	New Car Sales (millions)	Fleet Size (millions)	Vehicle miles (billions)
1975	9.1	102	1019
1990	14.2	142	1701
2000	16.1	177	2124
2020	26.2	239	2970

* Derived from Gas Consumption Model, Energy & Environmental Analysis, Inc. and from Bureau of the Census Population Forecasts.

B-8: SHARE OF NEW CAR SALES, BY CLASS					
Year	Subcompact	Compact	Intermediate	Standard	Luxury
1975	30%	24%	10%	23%	13%
1990	57	20	11	0	12
2000	57	20	11	0	12
2020	57	20	11	0	12

*Source: Gas Consumption Model, Energy & Environmental Analysis, Inc.

B-9: INDUSTRY CONVERSION COSTS (\$, billions)		
	Total Cost	Present Value
Non-Engine Redesign	7.5	6.5
Stratified Charge	3.8 *	3.8
Diesel	5.0 *	2.9
Stirling	7.9 *	4.6
Brayton	6.4 *	3.2

* Source: Jet Propulsion Laboratory: Should We Have a New Engine?(Aug.1975)

B-10: INCREMENTAL PURCHASE COSTS	
	Cost Per Vehicle
Non-engine Redesign	\$300
Stratified Charge	negligible
Diesel	\$ 52
Stirling	\$126
Brayton	\$ 12

* Source: Jet Propulsion Laboratory: Should We Have a New Engine?(Aug.1975)

total auto fleet only as old autos are replaced with improved models. Both effects were combined to calculate a weighted-average fuel consumption estimate for each class of auto each year. This average, then, was multiplied by vehicle miles traveled to estimate total auto fuel consumption for each year.

Three impacts associated with each auto fuel technology were considered: energy savings, extra purchase costs of more efficient autos, and costs to the auto industry of implementing each new technology. For each option, the annual incremental costs and savings were estimated through 2020. These were discounted to the present at 7 percent. The results are shown in Table B-11.

Table B-11: Net Benefits of Energy
Saved From New Auto Technologies

(\$, billions)

	Industry Conver- sion Costs	Incremental Purchase Costs	Fuel Savings Benefits	Net Benefits
Non-engine Redesign	6.5	55.2	120.7	59.0
Stratified Charge	3.8	negligible	24.5	20.7
Diesel Engine	2.9	3.4	29.7	23.4
Stirling	4.6	8.8	41.8	28.4
Brayton	3.2	.9	33.5	29.4
* Assumed fuel prices of .60/gal.				

APPENDIX C

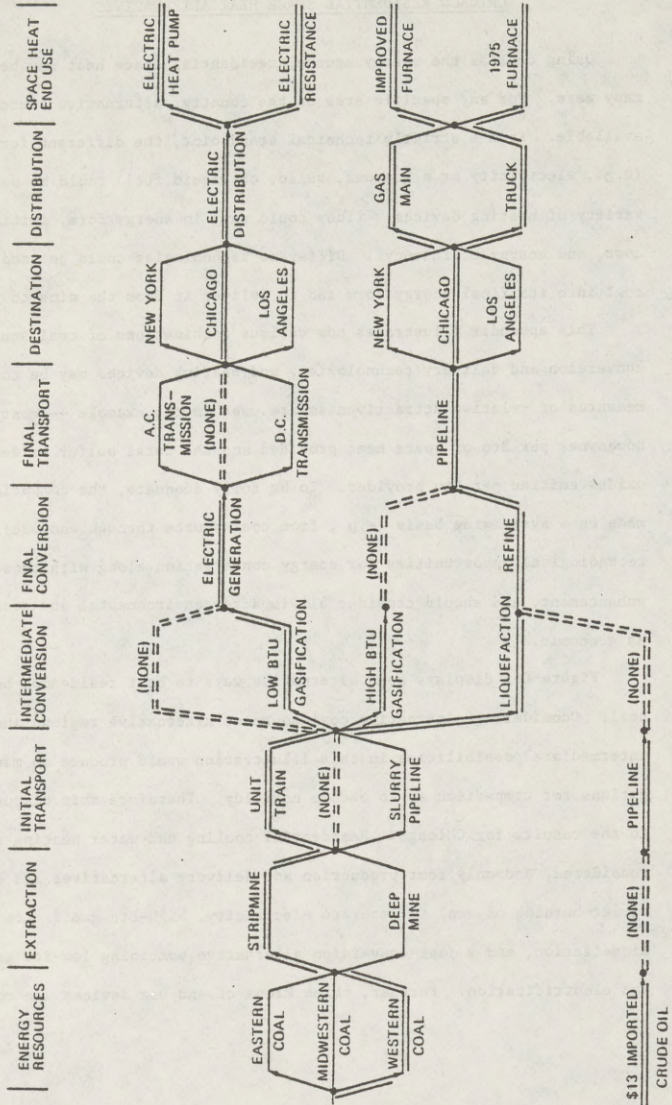
CHICAGO RESIDENTIAL SPACE HEAT ALTERNATIVES

Using coal as the energy source, residential space heat may be provided in many ways. For any specific area of the country, alternative sources of coal are available. From a strictly technical standpoint, the different forms of energy (e.g., electricity or a gaseous, solid, or liquid fuel) could be used in a variety of heating devices. (They could vary in energy form, initial cost, operating cost, and energy efficiency.) Different technologies could be used to convert the coal into its final energy form and to deliver it from the mine to the residence.

This appendix illustrates how various combinations of coal sources, conversion and delivery technologies, and heating devices may be compared. Two measures of relative attractiveness are used in the example -- cost to the homeowner per Btu of space heat provided and the total sulfur oxides and nitrogen oxides emitted per Btu provided. To be fully adequate, the comparisons should be made on a systemwide basis (e.g., from coal source through end use), should include technological opportunities for energy conservation along with those for supply enhancement, and should consider all impacts, environmental and social as well as economic.

Figure C-1 displays some alternative ways to heat residences beginning with coal. Considering alternative coal sources, alternative regions and all the intermediate possibilities in this illustration would produce so many systemwide options for comparison as to become unwieldy. Therefore this discussion is limited to the results for Chicago. Residential cooling and water heating are not considered, and only four production and delivery alternatives are compared: direct burning of coal to generate electricity, high-Btu gasification, coal liquefaction, and a dual-conversion alternative combining low-Btu gasification and electrification. Further, three kinds of end use devices are considered for

Figure C-1
Coal-Based Residential Heating Options



each energy form: today's furnace, a more efficient furnace, and an electric heat pump. Only the lowest-cost combination of coal sources and technical components for each of the four broad production and delivery alternatives are shown. (The double-lined pathways in Figure C-1 identify the four coal-based systems that result.) A system based on \$13 imported crude is included as a reference point for considering the implications of coal-based residential space heat.*

The process efficiencies attributed to the alternatives for Chicago space-heating comparisons are shown in Table C-1. From left to right, the efficiency of each step from extraction through each alternative end use is shown (the row labeled "increment"). To estimate the cumulative efficiency from extraction through any production, delivery, or end use step, the efficiency of each successive process step is combined by chain-multiplication.

Table C-2 shows the incremental and cumulative direct energy cost (per million Btus of space heat provided in the residence) at each step. For each, the incremental costs represent the midpoint of a range of process cost estimates for each conversion, delivery, and end use technology. Each estimate also represents full life-cycle costs associated with it, considering the capital investment required as well as the costs of energy and other direct inputs to the process. To derive systemwide costs, the increments at each step are added from left to right. The increment considers both the cost of the individual step as well as the additional costs caused at each previous step by any less than 100 percent energy efficiency of the step itself.

* The complete analysis for the cost and other impacts estimates shown here are presented in ICF Incorporated Alternative Coal-Using Technological Sequences for Residential Space Heat.

Table C-1: Five Alternatives for Chicago Residential Space Heat

OPTION	PROCESS EFFICIENCIES (useable Btu output/total Btu input)									
	PRODUCTION AND DELIVERY					END-USE				
	Extraction	Initial Transport	Initial Conversion	Final Conversion	Final Transportation	Distribution	1975 Furnace	Improved Furnace	Heat Pump	
DIRECTLY BURN WESTERN COAL TO GENERATE ELECTRICITY (Near-urban Generation)	*	1.0*	-	0.37	-	0.93	1.0**	-	2.84	
	1.0	1.0	1.0	0.37	0.37	0.35	0.35	-	1.04	
GASIFY WESTERN COAL TO PRODUCE HIGH-BTU PIPELINE QUALITY GAS	*	-	0.66	-	0.88	1.00	0.66	0.76	***	
	1.0	1.0	0.66	0.66	0.58	0.58	0.38	0.44	-	
GASIFY WESTERN COAL TO PRODUCE LOW-BTU GAS TO, IN TURN, GENERATE ELECTRICITY (Near-urban Generation)	*	1.0	0.82	0.40	-	0.93	1.0**	-	2.84	
	1.0	1.0	0.82	0.33	0.33	0.30	0.30	-	0.91	
LIQUIFY WESTERN COAL AND REFINES TO PRODUCE FUEL OIL	*	-	0.70	0.96	1.0*	1.00	0.53	0.63	***	
	1.0	1.0	0.70	0.67	0.67	0.67	0.36	0.42	-	
IMPORT \$13.00 CRUDE OIL AND REFINES TO PRODUCE FUEL OIL	*	-	-	0.96	1.0*	1.0	0.53	0.63	***	
	1.0	1.0	1.0	0.96	0.96	0.96	0.51	0.60	-	

* Efficiency chain begins at mine mouth; external energy inputs (e.g., to mine and transport) not considered in efficiency estimates.

** A relative measure of efficiency for a well-insulated electrical resistance heated home compared to an oil or gas heated home.

***, here, y-a at i no icl du d j van out onomads; sumf-assisted gas-heat not considered.

Table C-2: Five Alternatives for Chicago Residential Space Heat

OPTION	DIRECT ENERGY COST (\$/Btu x 10 ⁶)									
	PRODUCTION AND DELIVERY					END-USE				
	Extraction	Initial Transport	Initial Conversion	Final Conversion	Final Transport	Distribution	1975 Furnace	Improved Furnace	Heat Pump	
DIRECTLY BURN WESTERN COAL TO GENERATE ELECTRICITY (Near-urban Generation)	Increment	0.28	0.72	-	7.09	-	3.43	1.00	-	*
	---	---	---	---	---	---	---	---	---	---
	cumulative	0.28	1.00	1.00	8.09	8.09	11.52	12.52	-	9.74
GASIFY WESTERN COAL TO PRODUCE HIGH-BTU PIPELINE QUALITY GAS	Increment	0.28	-	3.64	-	0.81	0.83	5.28	4.18	**
	---	---	---	---	---	---	---	---	---	---
	cumulative	0.28	0.28	3.92	3.92	4.73	5.56	10.84	9.74	-
GASIFY WESTERN COAL TO PRODUCE LOW-BTU GAS TO, IN TURN, GENERATE ELECTRICITY (Near-urban Generation)	Increment	0.28	0.72	2.78	9.29	-	3.82	1.00	-	*
	---	---	---	---	---	---	---	---	---	---
	cumulative	0.28	1.00	3.78	13.07	13.07	16.89	17.89	-	11.60
LIQUIFY WESTERN COAL AND REFINE TO PRODUCE FUEL OIL	Increment	0.28	-	3.41	0.32	0.13	0.31	7.19	5.86	**
	---	---	---	---	---	---	---	---	---	---
	cumulative	0.28	0.28	3.69	4.01	4.14	4.45	11.65	10.31	-
IMPORT \$13.00 CRUDE OIL AND REFINE TO PRODUCE FUEL OIL	Increment	2.24	-	-	0.26	0.13	0.31	5.91	5.01	**
	---	---	---	---	---	---	---	---	---	---
	cumulative	2.24	2.24	2.24	2.50	2.69	3.00	8.91	8.01	-

* Assumes coefficient of performance of 2.8 ; a 2.0 coefficient increases total cost by 16 percent.

** Thermally-actuated heat pump not included due to disadvantageous economics; solar-assisted gas heat not considered.

Tables C-3 and C-4 show the systemwide incremental SO₂ and NO_x emissions associated with the alternatives. The increments at each process step are additive. At each step, however, the increment considers both the emission output of the individual step as well as the extra emissions caused at each previous step by any less than 100 percent energy efficiency of the step itself.

Table C-3: Five Alternatives for Chicago Residential Space Heat

OPTION	SYSTEMWIDE SULFUR DIOXIDE EMISSIONS (pounds/Btu x 10 ⁶)									
	PRODUCTION AND DELIVERY					END-USE				
	Extraction	Initial Transport	Initial Conversion	Final Conversion	Final Transport	Distribution	1975 Furnace	Improved Furnace	Heat Pump	
DIRECTLY BURN WESTERN COAL TO GENERATE ELECTRICITY (Near-urban Generation)	0	0.02	-	3.28	-	0.24	0	-	**	
	-	-	-	-	-	-	-	-	-	
cumulative	0	0.02	0.02	3.30	3.30	3.54	3.54	-	1.24	
GASIFY WESTERN COAL TO PRODUCE HIGH-BTU PIPELINE QUALITY GAS	0	-	0.04	-	0.01	0	0.03	0.02	***	
	-	-	-	-	-	-	-	-	-	
cumulative	0	0	0.04	0.04	0.05	0.05	0.08	0.07	-	
GASIFY WESTERN COAL TO PRODUCE LOW-BTU GAS TO, IN TURN, GENERATE ELECTRICITY (Near-urban Generation)	0	0.02	0.02	0.27	-	0.02	0	-	**	
	-	-	-	-	-	-	-	-	-	
cumulative	0	0.02	0.04	0.31	0.31	0.33	0.33	-	0.12	
LIQUIFY WESTERN COAL AND REFINE TO PRODUCE FUEL OIL	0	-	0.04	0.03	0	0	0.44	0.42	***	
	-	-	-	-	-	-	-	-	-	
cumulative	0	0	0.04	0.07	0.07	0.07	0.51	0.49	-	
IMPORT \$13.00 CRUDE OIL AND REFINE TO PRODUCE FUEL OIL	-	-	-	0.12	0	0	0.48	0.45	***	
	-	-	-	-	-	-	-	-	-	
cumulative	-	-	-	0.12	0.12	0.12	0.60	0.57	-	

* Emission increments at each step represent emissions produced directly by the individual activity (e.g., end-use) and the increased emissions produced at all early steps due to less than 100 percent efficiency of the individual activity.

** Assumes coefficient of performance of 2.8 ; a 2.0 coefficient increases pollution by 42%

*** Thermally-actuated heat pump not included due to disadvantageous economics; solar-assisted gas heat not considered.

Table C-4: Five Alternatives for Chicago Residential Space Heat

OPTION	SYSTEMWIDE NITROGEN OXIDES EMISSIONS (pound/btu x 10 ⁶)									
	PRODUCTION AND DELIVERY					END-USE				
	Extraction	Initial Transport	Initial Conversion	Final Conversion	Final Transportation	Distribution	1975 Furnace	Improved Furnace	Heat Pump	
DIRECTLY BURN WESTERN COAL TO GENERATE ELECTRICITY (Near-urban Generation)	Increment*	0.004	0.015	-	1.92	-	0	-	**	
	---	---	---	---	---	---	---	---	---	
	cumulative	0.004	0.02	0.02	1.94	2.08	2.08	-	.73	
GASIFY WESTERN COAL TO PRODUCE HIGH-BTU PIPELINE QUALITY GAS	Increment	0.004	-	0.18	-	0.26	0	0.25	***	
	---	---	---	---	---	---	---	---	---	
	cumulative	0.004	0.004	0.18	0.18	0.44	0.44	0.69	-	
GASIFY WESTERN COAL TO PRODUCE LOW-BTU GAS TO, IN TURN, GENERATE ELECTRICITY (Near-urban Generation)	Increment	0.004	0.02	0.03	0.58	-	0	-	**	
	---	---	---	---	---	---	---	---	---	
	cumulative	0.004	0.02	0.05	0.63	0.63	0.67	-	0.24	
LIQUIFY WESTERN COAL AND REFINES TO PRODUCE FUEL OIL	Increment	0.004	-	0.21	0.05	0	0	0.35	***	
	---	---	---	---	---	---	---	---	---	
	cumulative	0.004	0.004	0.21	0.26	0.26	0.26	0.61	-	
IMPORT \$13.00 CRUDE OIL AND REFINES TO PRODUCE FUEL OIL	Increment	-	-	-	0.02	0	0	0.21	***	
	---	---	---	---	---	---	---	---	---	
	cumulative	-	-	-	0.02	0.02	0.02	0.23	-	

* Emission increments at each step represent emissions produced directly by the individual activity (e.g., end-use) and the increased emissions produced at all early steps due to less than 100 percent efficiency of the individual activity.

** Assumes coefficient of performance of 2.8 ; a 2.0 coefficient increases pollution by 42%

*** Thermally-actuated heat pump not included due to disadvantages: solar-assisted gas heat not considered.

APPENDIX D

ENVIRONMENTAL BENEFITS OF THREE ENERGY CONSERVATION TECHNOLOGIES

Application of energy conservation technologies has two environmental effects. Using less energy reduces environmental impacts at points where energy is produced. At points of use, conservation technologies can increase or decrease various environmental impacts, compared to today's end-use devices. The sum of the production and use increases and decreases represent an environmental "dividend" from investment in conservation technologies.

Three technologies -- electric heat pumps, Stirling cycle auto engines, and industrial heat recuperators -- were selected to illustrate the net environmental benefits of energy conservation technologies. Their benefits depend upon the kinds of energy each conserve. Our estimates assume that heat pumps reduce electricity generated by coal-fired power plants. The other technologies reduce future production of synthetic oil and gas from coal.

In order to compare three different technologies, the environmental benefits provided by a \$1 million investment in each is used as a common denominator. This investment represents the extra cost to consumers to purchase those new technologies rather than the more conventional technologies in use today (see Table D-1).

For all three technologies the environmental benefits at points of production were calculated by multiplying the amount of energy conserved times powerplant, synthetic fuel plant, and coal mine emission and effluent rates per unit of energy produced. For auto engines, the reduction in auto emission provided by Stirling cycle engines, compared to today's engines also were factored in.

Table D-1: CHARACTERISTICS OF THREE CONSERVATION TECHNOLOGIES

	Heat Pump System	Stirling Cycle Engine	Heat Recuperator
Δ Initial Investment	\$2,200	\$300	\$50,000
Fuel form Conserved	Electricity: Coal-Fired Plants	Synthetic Gasoline from Coal	High-BTU Synthe- tic Gas from Coal
Fuel con- served per application *	40.9×10^6 BTU/yr	5.3 BBLS/yr	25×10^6 cu.ft./yr
Fuel con- served per million dollars	18.6×10^9 BTU/yr	17,665 BBLS/yr	500×10^6 cu.ft./yr
Location of Environmental Benefits			
• End Use Site	No	Yes	Yes
• Power Plant Site	Yes	No	No
• Synthetic Fuel Plant Site		Yes	Yes
• Mine Site	Yes	Yes	Yes

* Source: ERDA Office of Energy Conservation Programs

APPENDIX E

RESEARCH NEEDS ASSOCIATED WITH COAL-USING TECHNOLOGIES: EXTRACTION,
ECOLOGICAL AND MATERIALS EFFECTS

As noted in the body of this report, our examination of environmental R&D relative to coal-using technologies identified R&D needs in several areas besides process characterization and human health effects. Tables E-1, E-2, and E-3 list some environmental R&D needs associated with extraction, ecological and materials effects associated with the use of coal. These too are meant to be illustrative rather than definitive.

Table E-1
RESEARCH NEEDS FOR COAL EXTRACTION

MEDIUM PRIORITY	LOW PRIORITY
Study pilot mining operations	Methods of topographic restoration of abandoned mines
Develop better methods for management of mine spoil piles	Study the relation between revegetation and slope
Characterize leakage from slurry ponds and develop control methods	Evaluate reliability of landslide control techniques
Understand mechanism of alluvial valley floor disturbance and develop control methods	Characterize indirect effects of subsidence
Alleviate topsoil ruination during storage while strip mining is under way	Measure toxic metal concentrations in mine drainage
Evaluate wildlife habitat disturbance by mountaintop mining	Study dust production during mining
Characterize groundwater impacts of soil ridge erosion retardation	Study regrading
Characterize the indirect environmental impacts of flow control	Study vehicle emissions during mining
Learn to control erosion in arid and semi-arid areas	Study noise control
Control acid mine drainage	
Control salinity of waters near mines	
Understand effects of aquifer coal bed mining and learn to control them	
Develop methods of controlling aquifer disturbance	
Sedimentation studies	
Study stream diversion impacts	

Source: Based on Energy Resources Company, Inc. data.

Table E-2

RESEARCH NEEDS FOR ASSESSING ECOLOGICAL EFFECTS

MEDIUM PRIORITY	LOW PRIORITY
Develop early detection methods for ecological effects	Develop trapping, banding and radiotelemetry methods for surveys
Develop biological indicators	Characterize methods for soils
Study model ecosystems	Study uptake rates of pollutants in soils and foliage
Study rates, mechanisms and species involved in bioaccumulation	Study translocation in plants
Understand synergistic effects of stresses on ecosystems	Develop better archiving and retrieval of effects data on individual species and ecosystems
Learn toxicity (acute and chronic) of pollutants on plants and animals in freshwater and on land	Understand self-healing and remedial processes
Characterize regions potentially impacted by coal development	Develop models for different kinds and subelements of ecosystems
Monitor changes during development	
Investigate prevention and remedy of ecological changes	
Perform retrospective studies of ecological changes	
Conduct laboratory and field studies of growth inhibition and yield reduction in commercial crops	
Monitor environmental effects on crops	
Understand effects of physical and chemical parameters on ecosystems	
Develop a sensitive tissue assay method	

Source: Based on Energy Resources Company, Inc. data.

Table E-3
RESEARCH NEEDS FOR MATERIALS AND OTHER EFFECTS

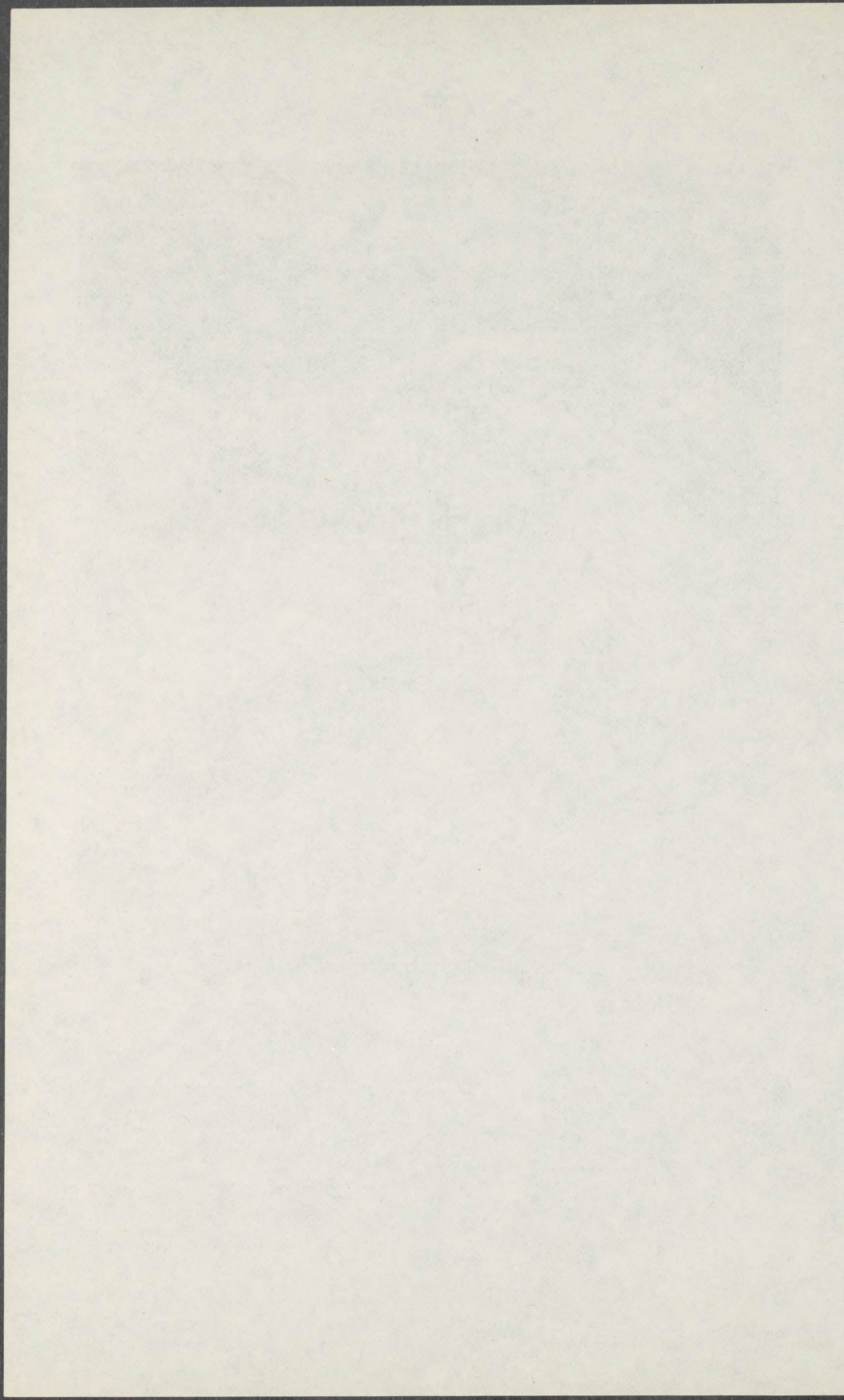
MEDIUM PRIORITY	LOW PRIORITY
Evaluate odor problem in synthetic liquid fuels	Understand mechanisms of building discoloration
Develop methods of removing odor from liquid fuels	Develop ways to control odors from coal conversion cooling towers
Evaluate economic consequences of clutter and identify areas where it would be a problem	Evaluate odor of tail gas and CO ₂ vent streams from conversion plants
	Evaluate nuisance value of introducing noisy coal conversion operations into undeveloped western areas

Source: Based on Energy Resources Company, Inc. data.

THE
IMPACT
OF
POWER PLANT
SITING
ON
CALIFORNIA'S
WATER
RESOURCES

association of california water agencies





THE IMPACT OF POWER PLANT SITING ON CALIFORNIA'S WATER RESOURCES

July 1976

This report was prepared for the
Association of California Water Agencies
by
Bookman-Edmonston Engineering, Inc.

"The Impact of Power Plant Siting on California's Water Resources" was prepared by John R. Teerink, vice president of Bookman-Edmonston Engineering, Inc. He is a former director of the California Department of Water Resources.

FOREWARD

Complex problems often are resolved with relatively simple solutions. The route to those solutions, however, is usually over a difficult road with many detours and roadblocks.

One of the increasingly complex problems facing California is the siting of thermal-electric plants. Growing concern over the past few years for environmental factors, seismic safety, preservation of the California coastline and others have compounded the problem.

Attempts to arrive at solutions since passage in 1972 of the California Coastal Zone Conservation Act by the statewide electorate have been somewhat narrow in approach. The problem often has been examined by the public agencies involved primarily from the single view point of the California coast. Basic factors to the public well being have been all but ignored. The problem involves the entire state and its economy. Failure to look at the full problem can result in repercussions affecting all parts of California and even impacting on the national economy as well.

This report is aimed at providing a more comprehensive look at the problem of thermal-electric plant siting. It specifically zeros in on the impact of energy production on the state's vital needs for fresh water for agricultural, industrial, domestic and other uses.

The interrelationship between California's water supply and electrical power needs is at the core of the problem. Electric power is needed to pump our groundwater supplies and most of the surface water that is delivered to the water deficient areas of the great Central Valley, the San Francisco Bay area and Southern California. In fact, the agricultural, industrial and domestic water needs of nearly all Californians depend on electric power.

At the same time, large quantities of fresh water are committed to cool thermal-electric power plants now in operation and those scheduled for construction in the near future. California water leaders recognize the need for energy to distribute the state's water, as well as the need for water for the process of generating electricity.

But, our fresh water resources are finite and must be conserved for agricultural, environmental, domestic and other uses for which alternative supplies are not available.

It is a complex problem, but there is a solution. California is uniquely situated geographically to use an inexhaustible water supply to cool thermal-electric power plants: the Pacific Ocean. The controversy that has surrounded development on the coast since the passage of the California Coastal Zone Conservation Act has made this simple solution complex. Much discussion has been generated among the environmentalists, power utilities, geologists, marine biologists, seismologists and water and power users.

This report gathers into one source the available data on California's water supply and demand, its power needs, the availability of sites on California's coastline for thermal-electric power plants and the inevitable seismic and environmental questions. It analyzes the potential impact of inland siting of

thermal-electric generating facilities upon our fresh water resources.

The report points out vividly that because of the existing and future demands for agricultural and urban water, it is much better to continue locating thermal-electric power plants on the coastline to use abundant ocean water for cooling than to commit ever greater quantities of our limited fresh water supplies for this purpose.

Our needs for more electrical power are here today! Parallel needs are growing for our limited fresh water supplies. Crucial decisions must be made now in order to conserve our fresh water supplies and at the same time provide the electricity needed by industry, agriculture and all of California's citizens.

Howard H. Hawkins
President
Association of California
Water Agencies

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INTRODUCTION

The use of electricity in California has increased in the years since World War II at a rate that has caused consumption to double every 10 years. Most of the additional generating capacity to meet the electrical demand has been provided by the construction of large thermal-electric power plants sited along the coastline to take advantage of the abundance of cooling water.

Physical and environmental problems have reduced the availability of suitable power plant sites, and the policies of regulatory agencies have made it increasingly difficult to construct additional power plants along the coastline. Concern for the coastline prompted the voters of California to adopt the 1972 Coastal Initiative (Proposition 20) which created the California Coastal Zone Conservation Commission with planning and control responsibilities.



Photo courtesy Southern California Edison Co.

Southern California Edison Co.'s Huntington Beach generating station uses ocean for cooling purposes.

The Commission has prepared the California Coastal Plan and submitted it to the Legislature for consideration and adoption. ^(1*) The aspect of the plan that deals with power plant siting is a major concern for the electric utilities and water supply agencies because of its far-reaching ramifications. Although the plan does not prohibit power plant siting per se on the coastline, the proposed policies and restrictions have that practical effect. The plan indicates that inland sites using evaporative cooling systems *shall* be preferred.

Several other studies have been made in recent years that have considered inland, as well as coastal, siting of thermal-electric power plants. ^(2,3,4,5) Most of these studies, as did the Coastal Plan, gave some recognition to the need for cooling water for power plants sited inland. They have, for the most part, however, not fully come to grips with the problems of water availability.

There is now a statewide deficiency in available water supplies to meet existing urban and agricultural uses. As these uses increase in the future, the deficiencies will continue to increase. Concern for the limited amounts of developed fresh water prompted the Association of California Water Agencies (ACWA) to adopt, on December 5, 1975, a resolution on water use and power plant siting. This resolution includes a policy of support for siting thermal-electric power plants along the coast because of the savings of fresh water. Recognition was also given by ACWA to the need to generate adequate electrical power for all purposes, including the very large requirements for pumping both urban and agricultural water supplies.

An action program undertaken by ACWA includes the development of current information on the availability of water supplies to meet all uses, including power plant cooling and the effect of power plant siting on those uses. The objective of this report is to provide information on the potential water requirement for cooling and other purposes, the availability of supplies to meet the requirements, and considerations of alternative power plant siting. Information has been gathered from the voluminous material available from many sources on the subjects covered in this report.

* Such numerical indications in text refer to sources listed in Reference section beginning on page 38.

I. SUMMARY AND CONCLUSIONS

California's water resources have a limited ability to supply the cooling water requirements for additional thermal-electric power plants that will be needed to meet the expected electrical load growth. There is an existing statewide water deficiency to meet the present urban and agricultural water demands, and this deficiency will continue to increase in the future from 1,370,000 acre-feet per year in 1980 to 2,250,000 acre-feet per year in 2000. Thermal-electric power plants with evaporative cooling systems using fresh water would increase that deficiency. The additional water requirements for power plant cooling, if these plants are sited inland instead of on the coast, would be 287,000 acre-feet by 1990 and 875,000 acre-feet by 2000.

The use of electricity has been growing at a rate of 8 percent per year over the past 35 years, but that growth is now slowing. The exponential growth rate has been largely caused by the combination of increasing population and the increasing use of electrical equipment.

The trend toward a slower population growth and an emphasis on energy conservation should continue to decrease the rate of electricity use during the next 25 years to about 4.4 percent per year. Even with a slowdown in electrical load growth, it is estimated that there will be an increase in demand over the use in 1975 of 27 percent by 1980, 96 percent by 1990, and 200 percent by 2000.

The installed generating capacity necessary to meet the demand for electrical energy will require additional construction of about 9,000 megawatts by 1980, 33,000 megawatts by 1990, and 72,000 megawatts by 2000.

The sources of generation supplying California's electrical demand in the past has come primarily from a mix of hydroelectric capacity, including sources in the Pacific northwest and on the Colorado River, and oil and gas fired steam electric capacity. In recent years, geothermal sources in California have been developed and coal fired plants in other states now contribute to energy generation. Three nuclear power plants are in operation in California, a fourth is under construction and several more are being planned. The future sources of additional power will include some limited hydroelectric, nuclear, and out-of-state hydroelectric and coal fired plants. Some increase in geothermal capacity is expected at the present site near the Geysers, with the Imperial Valley a potential for major development. Oil and gas fired units will also

contribute to the additional generation mix, particularly if the emissions can be controlled to acceptable levels. It is not expected that new methods of generating electricity by such means as solar energy, wind, tidal energy and other means will be developed sufficiently by the year 2000 to make any significant impact on the generation mix.

To meet the need for generating capacity during the next 25 years, several power plant sites will be selected in California. Some of these sites were included for limited capacity in legislation creating the State Energy Resource Conservation and Development Commission which was given the responsibility for power plant siting. At the present time, this responsibility is shared for coastal siting with the California Coastal Zone Conservation Commission.

The seismicity of California makes earthquake hazard the major concern in siting nuclear power plants. The criteria prescribed by the Nuclear Regulatory Commission (formerly the Atomic Energy Commission) places considerable importance on sites that

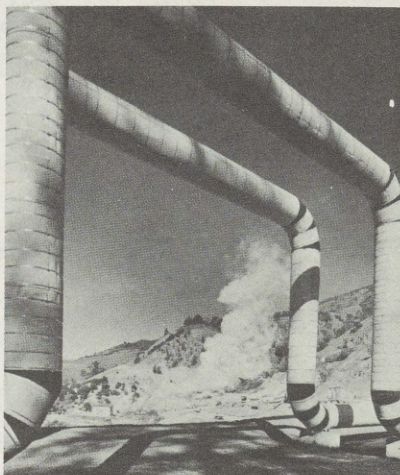


Photo courtesy Pacific Gas and Electric Co. Pacific Gas and Electric Co. plant in Sonoma County uses Geysers geothermal steam to produce electricity.

show no evidence of earthquake fault movement during the past 35,000 years. The Nuclear Regulating Commission has no specific criteria to exclude a nuclear power plant due to general seismicity of the area, but its very stringent criteria severely limit the suitable sites along most of the coastline and much of the inland area.

Once-through cooling with ocean water has been the method used for most of the thermal-electric generating capacity in California. If inland sites are used, other methods of condenser cooling will be required. The most likely system will be some type of mechanical draft or natural draft cooling towers. The amount of water consumed in the cooling process is dependent upon the characteristics of the power plant design and operation and other factors. The annual water requirement for a 1,000 megawatt power plant is about 15,000 acre-feet for fossil fuel fired and about 22,000 acre-feet for nuclear.

Nine of the state's eleven hydrologic areas that will be importing water through federal, state and local projects to meet water demands will depend upon Sacramento Valley water supplies tributary to the Sacramento-San Joaquin Delta. The only additional fresh water that can be developed in California is in the north coast and the Sacramento Valley. Twenty-five percent of the state's total runoff which occurs in the north coastal area is now precluded from development due to the Wild and Scenic Rivers Act and the additional supplies that can be developed in the Sacramento Valley are very limited.

Agricultural and municipal waste waters offer a potential to reduce the demand on fresh water supplies for evaporative cooling. By the year 2000, over 400,000 acre-feet of brackish agricultural drainage water per year will need to be removed from the San Joaquin Valley to maintain agricultural production. Approximately 1.3 million acre-feet of drainage water per year flows into the Salton Sea in the Imperial Valley and approximately 2.5 million acre-feet of municipal and industrial waste water is now processed each year with disposal into saline water. About 400,000 acre-feet of irrigation drainage is returned to the Colorado River from the Palo Verde Valley.

Despite the potential availability of waste water, it will require extensive and costly additional treatment to make it usable in power plant cooling systems. Biological treatment for removal of nutrients and softening would be required for most waste waters with additional demineralization required for the more brackish agricultural drainage waters. The added cost of collection and conveyance of the waste water to power plant sites would be extensive. Additional problems and costs would also be incurred in the disposal of the brine and other wastes from the water

treatment and cooling tower blowdown.

The problem of competing uses for scarce water supplies does not have an easy solution and it will increase as the requirements for water and power increase. The availability of the coastline to site power plants would decrease the water supply problems by providing additional options. Some conclusions regarding power plant siting are as follows:

- (1) Due to the many problems in siting power plants needed in California to meet the future electrical energy requirements, all available siting options should be kept open, including the coastline.
- (2) Uncertainties with coastal siting due to actions of regulatory agencies and other reasons are prompting the electric utilities to seek inland power plant sites to meet their electrical power demands in the 1980's.
- (3) Due to costs and the limitations for brine and sludge disposal, only part of the cooling water demand will come from waste water. Some fresh water will be required to supply the near-future demand.
- (4) To the extent that fresh water is used for power plant cooling, water deficiencies will increase, causing additional ground water overdraft in some areas.
- (5) There are limited siting possibilities for power plants on the coastline and each site should be investigated on its own merits. Some of these sites are a considerable distance from the load center to be served.
- (6) Other power plant siting concepts such as underground and off shore may be feasible but more study and detailed investigation would be required.
- (7) Some fossil fuel power plants may be constructed if the emissions problem is solved. Additional coastal sites would be practical for fossil fuel power plants without the constraints imposed upon nuclear plants due to seismicity.
- (8) Once-through cooling is a more efficient method than evaporative cooling and would be consistent with other energy conservation measures.
- (9) The effect on marine life due to thermal discharges at coastal power plants has not been a major problem in the vicinity of cooling water outfall pipelines. Replacement communities have developed where gaps were left by more sensitive species.

II. SOURCES OF POWER

The electricity consumed in California is generated by power plants from both within and outside of the state. There are five investor-owned electrical utilities and eight publicly-owned systems that generate and sell power to retail customers. In addition, there are eleven public agencies that own generating facilities that use the power themselves or wholesale it to one of the electrical utilities. There are also a number of municipalities and other agencies that distribute and sell power that is generated by others.

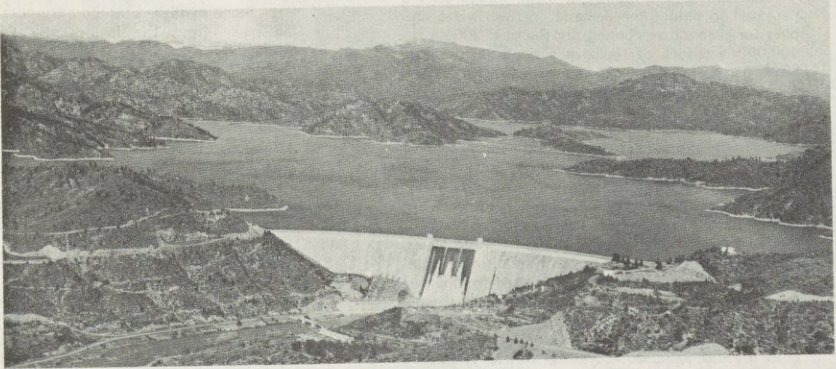
Hydroelectric

Falling water has been used to drive turbines and electrical generators in California since the 1890's. It continued to be the primary source of electrical power for the next half century. The first hydroelectric plants that were built were single purpose projects which used the run of the stream or stored water behind a dam for release at times when the power was needed. In later years, many water projects were constructed that supplied agricultural and municipal water and also generated power.

As the most feasible sites for dams and power plants were used first, the feasibility of additional hydroelectric generation has been reduced. There is

still a potential, however, to develop more hydroelectric power. The Department of Water Resources, in its Bulletin 194, "Hydroelectric Energy Potentials in California," indicated a near-future potential to expand the current hydroelectric output by about 30 percent. (6) There will be some addition to the present hydroelectric system as some of these are constructed. The financial feasibility and environmental impact of most of the required projects have not been determined, however. In 1975 the installed hydroelectric capacity in California was about 9024 megawatts.

The relative importance of hydroelectric power has declined until it now furnishes about 20 percent of the total electrical energy used. This decline in the share of energy generation will continue as the total demand for power increases at a more rapid rate than hydroelectric capability. Hydroelectric power will continue to serve an important role in the total electrical utility operation because of its ability to meet the peak load or demand. Hydraulic turbines can respond very quickly to changes in electrical load and so are very useful to meet the peak demands during a few hours of the day. The ability of hydroelectric plants to meet the peak power demands has been increased in recent years with the construction of pumped-storage plants. This type of development



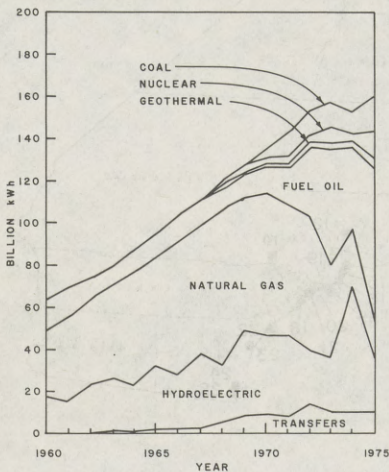
Hydroelectric generation at Shasta Dam in Northern California provides a clean source for electric power.

Limited potential still remains for development of additional hydropower and is now being studied.

Photo courtesy U.S. Bureau of Reclamation.

ELECTRIC GENERATING CAPACITY AVAILABLE TO MEET CALIFORNIA LOADS IN 1975

Source	Megawatts
Out of State	
Coal	2,259
Hydroelectric	1,125
Transfers	1,704
Subtotal	5,088
In State	
Hydroelectric	9,024
Oil and gas (steam)	21,889
Gas turbine	1,487
Diesel	62
Geothermal	502
Nuclear	1,395
Subtotal	34,359
Total of all sources	39,447



Source: Rand Corporation, "Energy Alternatives for California"

ELECTRICITY PRODUCED FOR USE IN CALIFORNIA BY SOURCE OF ENERGY

requires reservoir storage both above and below the power plant. It incorporates the use of a pump-turbine to generate power as water is released from above the plant during the peak demand hours. During the off-peak hours, the turbine is reversed to become a pump, and the generator is operated as a motor. This puts water back in the reservoir for use during the generating cycle. Pumped-storage operations consume more energy than is generated, but reduce the need for standby thermal-electric capacity and are important to the large electric utility systems in California.

Thermal-Electric

Thermal-electric plants use heat to produce either steam or gases to drive a turbine-generator. The most efficient method of generating large quantities of electricity by a thermal-electric plant is to use steam as the driving force. Steam may be produced by geothermal wells; by burning coal, oil or gas; or by the heat from nuclear fission. Future development of solar energy may also provide an additional source of heat to produce steam.

Oil and Gas. Relatively inexpensive oil and gas were favorable to the development of steam-generating units in the period since World War II. Progressively larger steam generators have been built and are well suited to meet the large increments of additional generating capacity. By 1975, about one-half of the energy generated in California came from oil-and-gas fired steam-electric plants. In that year there were about 21,889 megawatts of installed capacity.

There is some uncertainty as to the installation of

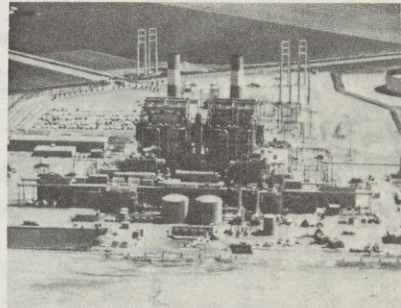
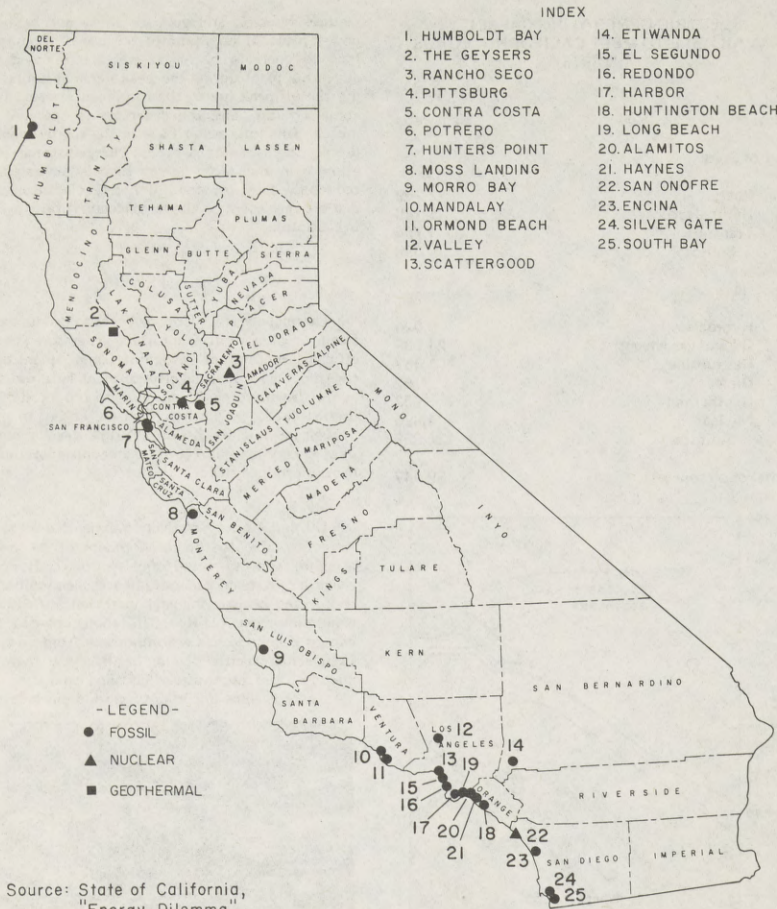


Photo courtesy Southern California Edison Co.
Southern California Edison Co. Ormond Beach generating station is conventional oil- and gas-fired plant.



MAJOR THERMAL POWER PLANTS IN CALIFORNIA
OPERATING IN 1975

future fossil fuel-fired power plants in California because of the problem of air quality. Natural gas is more desired as a fuel than oil, particularly in the critical air basins. This is further complicated, however, by the Federal Power Commission's present priority system of allocating scarce fuels. Efforts to develop cleaner-burning oil systems are continuing, and it is likely that oil and gas will continue to meet some of the future additions to the electrical generating capability.

Geothermal. In 1960, the first commercial geothermal generation of electricity in the United States began at the Geysers in Sonoma County. The geothermal resource in the vicinity of the Geysers is "vapor dominated," or dry steam. The steam produced from wells drives a turbine-generator and needs no additional heat supply. There were 502 megawatts of installed geothermal capacity by 1975. There is a potential for additional capacity in the Sonoma-Lake County area.

Another large geothermal potential is in the Imperial Valley, which is a "hot water dominated," or wet field. No commercial power production has occurred in the Imperial Valley, although a few miles south at Cerro Prieto, Mexico, the Mexican government has commenced a small commercial operation.

There are environmental problems of noise, odors, brine disposal, and subsidence that must be dealt with as additional geothermal resources are developed, particularly in the Imperial Valley. Exploration and investigation by the electric utilities and governmental agencies is being performed. The California Department of Conservation, in 1972, estimated that the geothermal generating capacity in California could be as much as 7,000 megawatts by

1990 if the Imperial Valley and other areas could be developed. (2)

Nuclear. In the late 1950's, the first commercial electric power was produced in California from a nuclear power plant using uranium as the fuel. The heat from the nuclear reaction is used to make steam which drives the turbine-generator. Nuclear power is planned to meet a growing portion of the electrical energy demand. There are now three operating nuclear power plants in California with a total capacity of 1,395 megawatts. These are at Humboldt Bay, San Onofre and Rancho Seco. A nuclear power plant at Diablo Canyon is under construction, and others are being planned.

Nuclear power plants are being opposed by numerous groups. An initiative measure on the June 1976 ballot in California, which would have severely curtailed, if not stopped, future construction of nuclear power plants in California, was defeated by the electorate.

Gas Turbine and Combined Cycle. Gas turbines use hot exhaust gases to drive a turbine-generator. The heat is dissipated to the atmosphere, and there is no cooling water requirement. The use of gas turbines has risen sharply in recent years as larger and more efficient units have been constructed. Because turbines are particularly adapted to fast start-up, they are used largely for peaking.

Various petroleum derivatives and natural gas are used as fuels for gas turbines. The emissions from gas turbines are an air pollution problem in critical air basins. In 1975, there were approximately 1,487 megawatts of installed capacity provided by gas turbines.

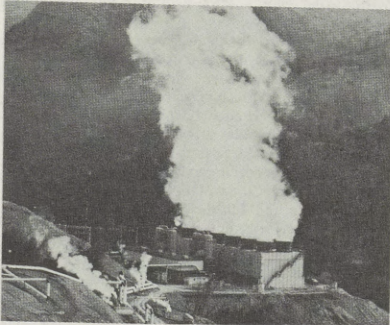


Photo courtesy Pacific Gas and Electric Co. Pacific Gas and Electric Co. Sonoma County geothermal plant has 502 megawatts of installed capacity.

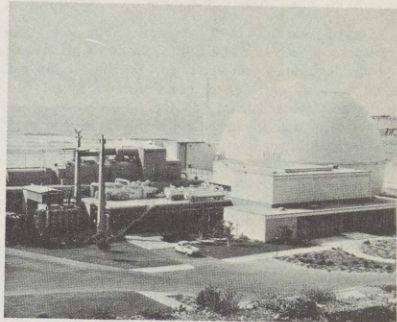


Photo courtesy Southern California Edison Co. San Onofre nuclear power plant in Southern California is one of three plants in operation in the state.

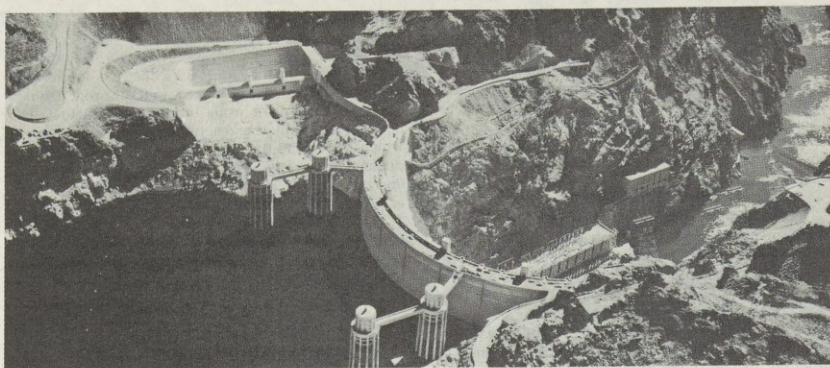


Photo courtesy U.S. Bureau of Reclamation.

Hoover Dam on the Colorado River provides hydroelectric power to California. The state imports 5,088

An extension of the use of gas turbines planned for the future is possible by combining them with steam generating units. Such a combined-cycle plant might obtain about 50-75 percent of the power from the gas turbine and the remainder from the steam unit, using the combination products of the gas turbine as the heat source. Since the condenser of the steam unit would require cooling, there would be a cooling water requirement for combined-cycle power plants.

Out-of-State Sources

Out-of-state sources of electrical energy have been important in meeting the California demands. These sources include power from the Pacific Northwest and from Hoover Dam on the Colorado River. The electrical transfers from the Pacific Northwest are subject to change as the power demands in that area increase and power is withdrawn.

Coal-fired steam electric plants in the states of Arizona, Nevada, New Mexico and Washington provide part of the available resources for power. There are no coal-fired plants in California. Expansion of existing plants and additional installations are being planned. Environmental opposition to siting coal-fired plants in the southwestern deserts gives some uncertainty as to the future generating capacity from those sources.

The installation of all types of generating capacity in other western states will continue to satisfy a significant portion of California's demand. The electrical

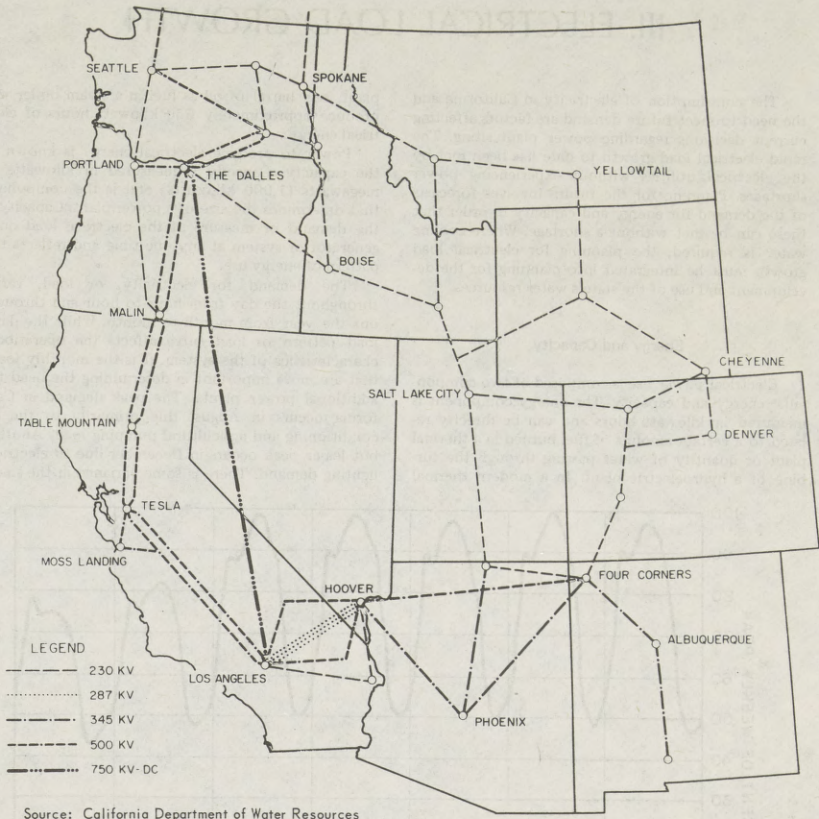
megawatts of power from out-of-state sources, compared to some 34,359 megawatts from in-state.

interconnection of the major western electrical utilities will facilitate transfers of electrical power to California and throughout the West. In 1975, there were approximately 5,088 megawatts of out-of-state capacity available to California.

Alternative Sources

Alternative sources of energy to generate electricity are widely discussed, and some research and development is taking place. Some of the concepts receiving attention include fission power, fast breeder reactors, solar energy, wind energy, tidal energy and fuel from solid wastes. (5)

The extent to which methods of generation different from present methods will contribute to the generation mix is unknown. No determination can be made at this time as to the feasibility of these alternative concepts, nor when they might assume a significant roll in meeting the power demands. Where the energy source provides heat for a steam boiler, there will probably be a cooling water requirement similar to conventional methods. Many years of development are usually required for the technology to be developed and it does not appear that they will relieve the power plant siting problem during the next 25 years. For example, in 1963, the State of California entered into an agreement with the Atomic Energy Commission with the expectation of a pilot project using a breeder reactor to provide pumping power for the State Water Project. (7) Due to technical difficulties, this was abandoned, and the breeder reactor remains a development for the future.



MAJOR TRANSMISSION LINES SERVING THE WESTERN STATES

III. ELECTRICAL LOAD GROWTH

The consumption of electricity in California and the need to meet future demand are factors affecting current decisions regarding power plant siting. The rapid electrical load growth to date has been met by the electrical utilities without experiencing power shortages. Planning for the future involves forecasts of the demand for energy and capacity in order that these can be met without a shortage. Where cooling water is required, the planning for electrical load growth must be integrated into planning for the development and use of the state's water resources.

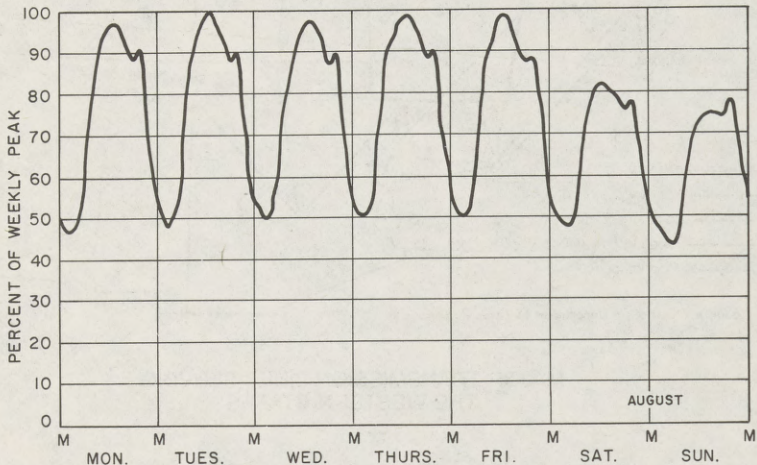
Energy and Capacity

Electrical power use is composed of two components—energy and capacity. The energy component is measured in kilowatt hours and can be directly related to a certain amount of fuel burned in a thermal plant or quantity of water passing through the turbine of a hydroelectric plant. In a modern thermal

plant, one barrel of oil as fuel in a steam boiler will produce approximately 650 kilowatt hours of electrical energy.

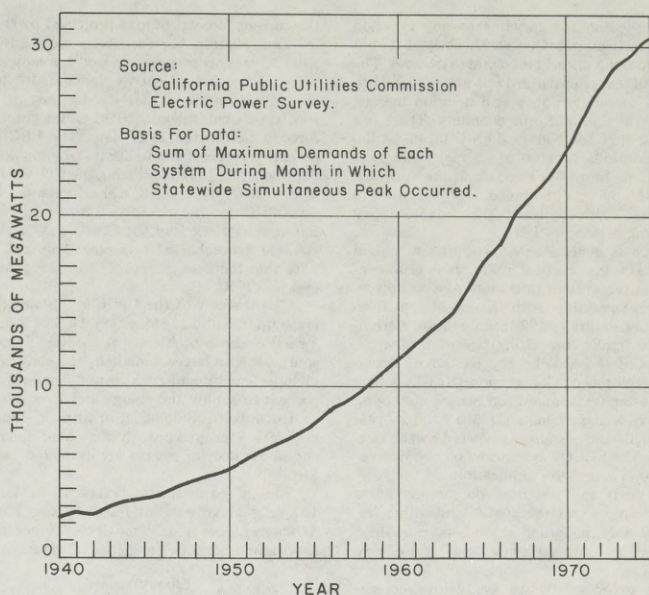
Power to produce electrical energy is known as the capacity. Capacity is measured in kilowatts or megawatts (1,000 kilowatts) and is the component that determines the size of a power plant. Capacity is the demand or measure of the electrical load on a generator or system at any one time and reflects the pattern of energy use.

The demand for electricity, or load, varies throughout the day from hour to hour and throughout the year from month to month. While the daily load pattern or load curve affects the operational characteristics of the system, it is the monthly loads that are more important in determining the need for additional power plants. The peak demand in California occurs in August due primarily to the air conditioning and agricultural pumping load. Another but lesser peak occurs in December due to electrical lighting demand. There is some variance in the shape



Source: Los Angeles Department of Water and Power

LOAD VARIATIONS FOR A TYPICAL POWER SYSTEM



MAXIMUM DEMAND IN CALIFORNIA, 1940-1975

of the load curve during the year for the different electrical systems serving California. This results from different climatic and economic factors within the system served.

In order that the electrical utilities can meet the peak power demands, they must maintain a reserve capacity. The reserve capacity allows units to be off the line while undergoing scheduled maintenance and provides standby units available to pick up the load in the event of a sudden failure or outage of generating or transmission equipment. As generating units have become larger, the potential for larger percentage of capacity loss under contingency conditions exists. High pressure steam units increase the probability of failure. This reserve capacity has been about 15 percent of the peak load, but in recent years has increased to about 20 percent.

Forecast of Future Power Demand

Electricity consumption has been increasing in California at a compound growth rate of nearly 8 per-

cent per year during the past 35 years. The California Public Utilities Commission (CPUC) has reported this annual rate of growth at 8.35 percent in the decade of the 1950's and slowing to the current growth rate of 5.1 percent.⁽⁸⁾

Numerous forecasts have been made of future power demands. The electrical utilities have made forecasts in planning additions to their systems, and are required to submit these to the CPUC. The CPUC also forecasts loads and resources of the electrical utilities and annually issues 10-year forecasts with those of the utilities. Comprehensive studies of energy use and forecasts were made by the Rand Corporation for the California Resources Agency in 1972 and for the California State Assembly in 1975.^(9,5) Other forecasts have been reported to the Legislature from studies made at the Environmental Quality Laboratory, California Institute of Technology.⁽¹⁰⁾

Growth in the use of electricity results from several causes: (1) increase in population, (2) increase in standard of living, (3) development of new applications for uses of electrical equipment, and (4) shifts from other forms of energy sources to electricity.

Because of the combined growth rate, any variation in these factors can result in significantly different values when looking ahead two or three decades. The implications of exponential growth are very significant in terms of public policy and decision making for all sectors of the California economy. There is a general feeling that the electrical growth rate of the past cannot continue because of its many ramifications for the long term. For example, if the historical growth rate of 8 percent continued, it would result in the need to install annually by 2000 as much capacity as the total peak demand in 1975.

While there is general agreement that increased load growth has some practical limits, there is no consensus on what the growth rate should be or how to achieve it. Dissatisfaction with the traditional forecasts led the Legislature in 1974, through the Warren-Alquist Act, to make forecasting one of the important functions of the new Energy Resource Conservation and Development Commission (ERCDC). The ERCDC is to establish standard forecasting methodology and to review and evaluate the 5, 10 and 20-year forecasts of loads and resources prepared by the electrical utilities. The ERCDC is required by the Warren-Alquist Act to examine the implications of the forecast level of loads and resources on, among other things, the "critical environmental and other resources of the state, including air and water quality, coastal, natural, and other unique areas, and energy resources."

The desire expressed by the Legislature, conservation groups and others to slow the rate of growth of electrical consumption has focused on the measures that would act as restraint of growth. The ERCDC has the responsibility to encourage the reduction of electrical demand through its policies and actions. The California Coastal Zone Conservation Commission has suggested that vigorous energy conservation measures would lessen the impact and need for new power plants. (1) Such measures might include price rate restructuring and the development of new energy sources. Slower population and economic growth and increased cost of electricity due to rising fuel costs would also slow the rate of demand for electricity. The CZCC suggests that the estimated demand for electricity could be reduced by 30 to 40 percent of the conventional projections for the year 2000.

A thorough, in-depth analysis has not been made that deals with all of the ramifications of the kind of actions necessary to achieve the reduction in electrical demand that the CZCC sees possible. The change in life style and economic side effects may not be desired or accepted by society. The uncertainty as to the extent of possible curtailment in electrical energy use and the long lead time to bring new power plants on the line requires the utilities to plan now to meet

the current forecast of load projected by the CPUC.

The Warren-Alquist Act specified that the ERCDC was to prepare a report by January 1, 1977 with its forecast of energy demand. In the interim, the Act determined that the forecast of the CPUC was to be used unless ERCDC could prepare its own forecast before the 1977 date. The ERCDC did not prepare a forecast and under its Opinion and Order of September 2, 1975 is utilizing the CPUC forecast. (11) The staff of the ERCDC did criticize the forecast of the CPUC and the electric utilities, and indicated the methodology used by the CPUC was "seriously deficient in a number of respects." The staff report implies that the load growth will be less than that forecast by CPUC.

The forecast of the CPUC is contained in its General Order No. 131, May 19, 1975, "Report on 10-Year Forecasts of Electrical Utilities' Loads and Resources." The forecast made by the staff of the CPUC includes energy and peak power demands and the resources to supply the energy and meet the peak power demands. Consideration of historic energy growth, population projections, system load factors, losses, and allowance for reserve are evaluated in making its forecasts.

Energy requirements as forecast in General Order 131 reflect a growth rate for the period 1975-1984 of 4.7 percent per year. The CPUC forecast of energy and summer peak demand is as follows:

	Energy (billions of kilowatt hours)	Peak Demand (megawatts)
1975	162	30,340
1978	188	35,840
1981	215	41,460
1984	245	47,350

The generating capacity as a resource to meet the peak demand would be greater than the demand by the amount of reserve for maintenance and contingencies.

The uncertainty that is inherent in forecasts of electrical load growth requires planning for a range of possibilities. The further out in time one goes, the broader the range to encompass the possibilities. Such a range of forecasts was reported by the Rand Corporation in its study for the California Resources Agency. (9)

The Rand study depicted a base case and four other cases. These cases, or scenarios, considered various combinations of possible population growth, economic growth, costs of fuel for energy, technological development, and other factors. The average growth rate for the five cases varied from 3.4 percent to 6.3 percent. The range in annual electricity gener-

ation from the lowest to the highest as projected in the Rand study for the five cases is summarized as follows:

	Energy (billions kwh)
1980	199-264
1990	272-491
2000	365-854

The difficulty of planning future facilities for such a range of possibilities is obvious. It is possible, however, to select a most probable single projection for planning purposes, adjusting to reflect changing conditions. For purpose of this report, a single projected load growth was used that reflects a slowdown in population growth, rising energy costs, and emphasis on conservation. An average rate of growth of 4.4 percent was used. This is the growth rate used in the CPUC 1981-84 projections and approximates the second lowest Rand projection.

The electrical utility system must have capacity to meet the varying demands during the year as they occur. The ratio of the yearly average generation to the peak generation during the year is the system load factor. This load factor varies for the different California utilities, but is about 60 percent. For a 100 percent load factor, one kilowatt of generating capacity operating continuously for one year would gener-

ate 8,760 kilowatt hours of electricity. With a load factor of 60 percent, one kilowatt of capacity would produce 5,256 kilowatt hours of electricity.

Peak demands projected for this report were determined to meet the annual generation requirement using a 60 percent load factor. The required installed capacity determines the number of generating units that need to be sited. A reserve factor of 20 percent was applied to the peak demand to make allowance for contingencies and scheduled shutdown for maintenance.

The projected generation requirements and installed capacity to meet those requirements are shown in the following tabulation:

	Generation (billions kilowatt hours)	Installed Capacity (megawatts)
1980	206	48,000
1990	317	72,000
2000	487	111,000

Not included in these projections is the requirement to replace existing plants as they become obsolete and are retired. Should existing plants be required to relocate for any reason, additional capacity to be sited would result.

IV. POWER PLANT SITING

Power plant siting is a complex decision-making process that involves numerous physical, environmental, social and economic factors. The major electrical utilities maintain a continuing program of planning for power plant sites with the selection of specific sites being made following regional studies. A lead time of 10 to 15 years is considered necessary to bring a nuclear power plant into operation after a specific site has been selected. Fossil fuel plants require about one-half the lead time as nuclear plants due to less detailed safety analyses and design. Regional studies are made for plant sites as much as 20 years in advance to meet the anticipated load growth.

In recent years the siting of power plants has become increasingly difficult as constraints due to regulatory legislation, litigation, changes in public attitudes, and broad energy-environmental concerns have emerged. For purposes of understanding the water supply-power plant siting issue, this report is mainly concerned with the physical and environmental considerations.

Physical Considerations

Physical considerations in site selection include those factors which are essential to be able to construct and operate a power plant. It is obvious that a hydroelectric plant would have to be located in close proximity to a reservoir or other source of falling water. A geothermal plant would have to be located over the source of geothermal fluid. For a fossil fuel or nuclear power plant, more flexibility is available because the fuel source does not pose the same constraints. Even where coal is the source of fuel, a thermal plant may be located hundreds of miles from the mine with the coal transported by rail or slurry pipeline.

There are several important physical limitations that severely restrict the number of suitable locations for power plant sites in California. Seismicity, suitability of geologic conditions and a source of cooling water are among the most important physical considerations in power plant siting.

Seismicity. California has been called "earthquake country" and due to the many active faults, seismic hazards are a major concern in siting nuclear power plants. Although the Nuclear Regulatory Commission (NRC) has no specific criteria that absolutely exclude the location of a nuclear power plant due to

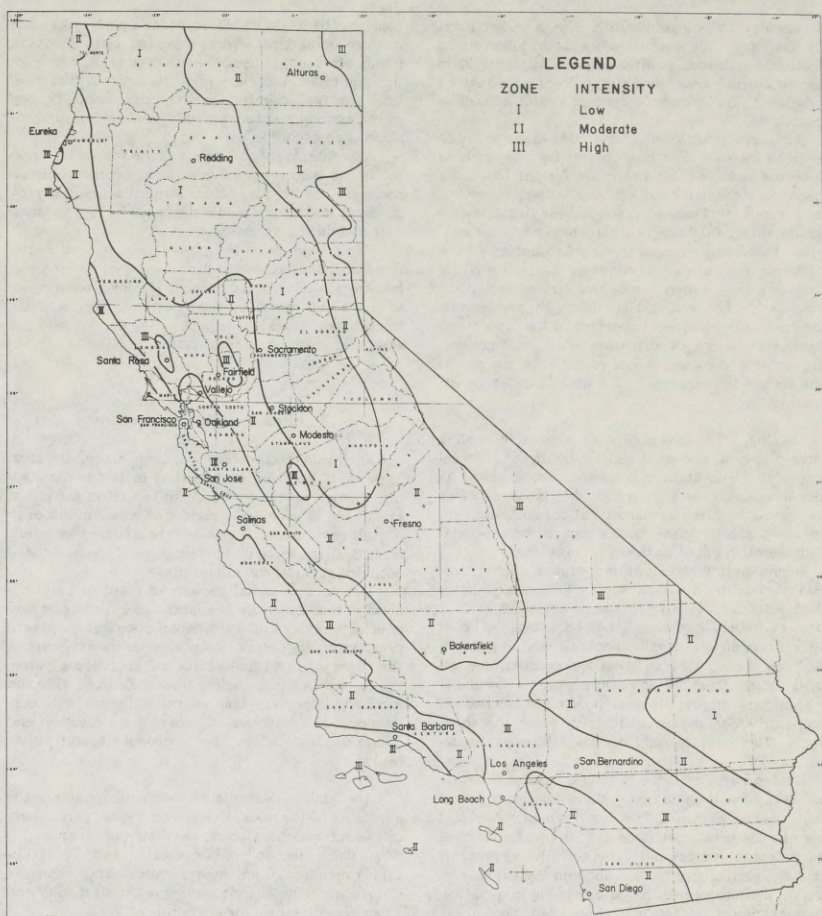
seismicity at the site, its guidelines for all practical purposes eliminate much of the area in California from site consideration. ⁽¹²⁾ The Atomic Energy Commission (predecessor to the NRC) included seismic and geologic siting criteria for nuclear power plants as a part of reactor site criteria under its rules and regulations, December 5, 1963. The methodology for determining the zone subject to faulting is set forth and the kind of investigation to accompany an application for siting in such a zone is prescribed. Concern of the NRC stems in part from the state-of-the-art of earthquake engineering technology.

Earthquake engineering is a developing field and is encumbered by a scarcity of statistical data to make estimates with confidence of the probability of recurrence of strong earthquakes in any given part of the state. Major earthquakes have been scattered geographically with no two occurring in the same area in historic time. The response of structures to strong shaking and ground motion has been under recent intensive investigation.

In an application to the NRC, the burden of establishing the seismic acceptability of a site rests upon the applicant utility. The NRC attaches considerable importance to the safe shutdown earthquake that the applicant is required to determine. This is the maximum credible earthquake that can be expected to affect the site. For nuclear plants the NRC considers a fault to be active if evidence indicates that movement has occurred along the fault at least once in the past 35,000 years or more than once in the past 500,000 years.

The imposition of criteria established by the NRC severely limits the potential sites for a nuclear power plant. Although a power plant might be designed to withstand the forces due to an earthquake of any magnitude that may occur in any part of the state, the practical considerations of cost and acceptability probably eliminate the areas of highest earthquake intensity.

The California Division of Mines and Geology has mapped the state to indicate the areas of maximum expectable earthquake intensity. ⁽¹³⁾ If criteria were used that eliminated the areas of major earthquake intensity, much of the state, including nearly one-half of the coastline, would be excluded from consideration for a nuclear power plant. The moderate intensity zone includes most of the remaining coastline with the minor to moderate zone accounting for essentially none of the coastline.



Source: California Division of Mines and Geology,
 "Urban Geology - Master Plan for California,
 December 1971"

PRELIMINARY MAP OF MAXIMUM EXPECTABLE EARTHQUAKE INTENSITY IN CALIFORNIA

Geology. Geologic conditions at a power plant site apart from the seismicity is a factor affecting its location. Landslides, mudflows, slope instability, and land subsidence are among the geologic hazards to be considered. These hazards exist at inland as well as coastal sites.

In recent years studies have been made in an attempt to increase the siting options for power plants along the coastline. Studies made for the California Resources Agency looked at several siting concepts of the future. ⁽²⁾ These included hillside siting, underground siting, offshore floating sites and other concepts. The Environmental Quality Laboratory of the California Institute of Technology has reported its evaluation of underground nuclear power plant siting. ⁽¹⁴⁾ The geologic condition of the foundation rock is particularly important in the layout and engineering design of structures sited underground. The strength and competence of the rock are important factors in determining the suitability for underground siting.

Cooling. The availability of a suitable cooling water supply is one of the most significant physical factors in the location of a thermal power plant. As once-through cooling provides the most efficient cooling method, the availability of an abundant supply along the coastline makes such siting the most desirable when only this factor is considered.

Inland sites that require evaporative cooling processes depend on a reliable supply of suitable quality water sufficiently close to the power plant so that water conveyance costs will not be excessive. Fresh water from surface developments as well as groundwater are being used to meet the consumptive demand. Where fresh water resources are not available in abundant supply, thermal power plants create a competitive demand with other uses for the short supply. This is more fully discussed later in this report.

Wastewater is available in several areas of the state that could be used to meet the evaporative power plant cooling demand. The San Francisco Bay and Los Angeles areas have large quantities of municipal and industrial wastewater. The agricultural areas of the state, particularly the San Joaquin Valley, have irrigation drainage water that is increasing in quantity. Thermal power plants could be sited near these sources. Wastewater use has limitations that need to be considered and these are more fully discussed later in this report.

Other Factors. Other factors that are included in physical considerations of thermal power plant siting include land use, transportation, and proximity to load center.

The land area required for a large thermal power

plant can be less than 100 acres for a plant with once-through cooling to several thousand acres if cooling ponds are used. Nuclear plants require less area for the plant facilities than fossil fuel plants that need land for fuel storage. On the other hand, nuclear plants are required to have additional land around the plant as an exclusion area.

Accessibility of the power plant site to transportation of heavy equipment during construction is necessary. Fossil fuel plants require accessibility by pipeline, tanker or other conveyance facility to transport fuel during operation.

The proximity of the power plant to load center is a factor that affects cost and energy loss for transmission. In California, the major load centers are within a few miles of the coastline. The need for transmission corridors and their impact on land use and other values is a consideration.

Environmental Considerations

Environmental considerations are among the most important problems encountered in power plant siting. Changes in the environment can affect the public safety and as such are a matter of concern, although not all environmental changes are a hazard to public health. There are environmental problems associated with both coastal and inland sites.

The environmental impacts of fossil fuel and nuclear power plants are similar for such factors as visual effects, water quality, thermal discharges, and land use. Air quality deterioration is primarily a concern in the siting of fossil fuel plants and radiation a potential hazard in siting nuclear plants. Federal, state and local regulatory agencies maintain considerable control over the activities of power plant location and operation that affect the environment and public health.

Air Quality. Air quality varies greatly among the air basins of the state. Certain air basins, particularly in the metropolitan areas, have air pollution that is now damaging to public health. ⁽¹⁵⁾ This pollution originates from many sources and extensive efforts are being made to improve the air quality and lessen the effects on the environment.

Power plants that burn fossil fuels are particularly subject to stringent control of emissions. Local regulations applicable to fossil fuel plants in California in seven of the eleven air basins are more stringent than the federal regulations. In view of these emission regulations, fossil fuel plants sited in California will need to incorporate low-emission technology and to obtain cleaner burning fuels such as natural gas and low sulfur oil.

Public Safety. Under the Atomic Energy Act of 1954, the Atomic Energy Commission (now Nuclear Regulatory Commission) is responsible for protecting the health and safety of the public from radiation hazards through its authority to license and regulate nuclear power generation.

In the Atomic Energy Commission Reactor Site Criteria issued December 5, 1973, several factors are to be considered when evaluating nuclear power plant sites. These include: (a) characteristics of reactor design and proposed operation, (b) population density and use characteristics of the site environs, including the exclusion area, low population zone, and population center distance, and (c) physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

The factors that make up the population density factors include the following:

"Exclusion area" means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area.

"Low population zone" means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident.

"Population center distance" means the distance from the reactor to the nearest boundary of a densely populated center containing more than 25,000 residents.

The AEC criteria does not give absolute fixed values for separation distances between population centers and nuclear reactors. Technological advances in reactor design in recent years have resulted in increased safeguards for the public. As nuclear reactor sizes have increased and suitable sites have decreased, there has been increasing reliance on the employment of engineered safeguards in lieu of population separation. The distribution of population around nuclear power plants has been used as a criterion when comparing a potential power plant site with other nuclear plants licensed by the AEC.

Thermal Discharge Effects. The discharge of heated cooling water from thermal electric power plants using once-through cooling may cause physical and biological changes that may be beneficial, detrimental or negligible, depending on the ecology of the

receiving water. The rise in temperature of the discharged cooling water may range from 10 to 20 degrees F.

The State Water Resources Control Board has adopted regulations that pertain to the dispersal of heat from waste discharges that include those from thermal electric power plants. (16) The SWRCB report, "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" (May 18, 1972, last revised September 18, 1975) refers only to coastal and interstate waters; however, the effect of the regulations is to preclude once-through cooling for inland waters.

Under the SWRCB requirements for new discharges, the maximum temperature of the discharged cooling water, classified by the Board as thermal waste, may not exceed the temperature of the receiving water by more than 2 degrees F. The natural temperature of the receiving water may not be elevated more than 4 degrees F at the shoreline, at the surface of any substrate, or at the ocean surface more than 1,000 feet from the point of discharge. Surface temperature limitations must be maintained during at least 50 percent of a complete tidal cycle.

Ecological impacts on marine life from thermal discharges have been extensively assessed by both field and laboratory methods. Evidence from laboratory studies indicates that acclimation by some species to elevated temperature is possible within limits. (17)

The ocean environment is complex with changes of the thermal layer under natural conditions taking place due to solar heating and mixing from wind and waves. Marine organisms under natural conditions may experience daily temperature fluctuations of 10 degrees F or more.

Power plants discharging heated cooling water into the ocean disperse the heat near shore by returning the water in a canal, or it is dispersed offshore by use of outfall pipelines with either a single riser or a diffuser. In the typical marine discharge, most extreme conditions exist at the discharge point, grading to ambient levels some distance away. Gradients occur in communities of benthic (bottom) organisms surrounding discharge sites. Precise nature of these distributions depends on characteristics of each locality but the typical pattern indicates that the higher the temperature and the greater the exposure period, the more profound the change.

Some benthic (associated with the bottom) organisms such as fishes and crustaceans are sufficiently mobile to avoid conditions that are adverse physiologically. Many sedentary or slowly moving benthic creatures tolerate changes as best they can or succumb. Frequently gaps left by sensitive species are filled by increased numbers of insensitive plants and

animals and a "replacement" community develops.

Thermal effects may vary with the season. While organisms may acclimatize to warmer conditions as summer approaches, additional heat loading due to thermal discharges may exceed acclimation potentials. Species inhabiting cooler waters can frequently withstand moderate exposures to temperatures many degrees above normal environmental levels.

Organisms that inhabit the free-water region of the sea may encounter thermal effluents briefly if they enter the heated mass as it disperses. They may also be subjected to longer exposures if they are drawn into the cooling water system and they may be damaged by pumps and other features of the system.

The heat dispersal area of the ocean receiving water is affected by the flow of cooling water and the prevailing wind and current characteristics. For a 1,000 megawatt thermal electric plant, a cooling water flow of 1,500 to 1,800 cubic feet per second is required. Infrared surveys along the California coastline have made it possible to plot the surface area where the temperature was increased by 2 degrees F and 10 degrees F above ambient. For power generation of 1,000 megawatts, the largest dispersal areas were 10 to 20 acres for the 10 degree F increase and 600 to 700 acres for the 2 degree F increase.

Circulating seawater may influence marine organisms that become entrained in the cooling system. Particular interest has been expressed as to the fates of planktonic plants (phytoplankton) and animals (zooplankton). Plankton refers to organisms whose swimming activities are so weak that they are unable to control their geographical locations by overcoming transport due to currents.

A number of ecologically or commercially important organisms occur as plankton at early stages of their life cycles. If cooling systems were to adversely affect these planktonic organisms, and if a significant proportion of the total population were drawn in, the effects could be far reaching. Such far reaching effects have never been observed along the California coastline. Entrained organisms might be affected by thermal shock, by physical damage from turbulence or impaction, or by various kinds of chemical treatment.

Results from the different studies have been highly variable, often reflecting influence of special circumstances associated with a particular installation. Substantial sampling difficulties typically arise from extremely heterogeneous spatial and temporal distributions of plankton populations.

Apparent mortalities of one species of plankton ranged from 9 percent to 29 percent at the San Onofre nuclear power plant and from 22 percent to 37 percent at the Encina power plant in San Diego County. (18) The numbers of larvae are usually so small that statistically reliable data are difficult to obtain.

Laboratory studies have been made to evaluate stressful factors. Studies were made for Pacific Gas & Electric Company using the larvae of the red abalone. (19) Mortalities did not significantly differ between the control groups and the test groups subjected to a temperature elevation of 24 degrees F above the ambient level of 63 degrees F for 10 minutes. General studies at operating power plants in California have indicated only modest mortality rates for broad categories such as phytoplankton and zooplankton and relatively small effects on larvae. (18,20)

A number of careful thermal effect studies have been published since 1973 concerning operating power plants in California. (21,22,23) The primary purpose of these projects has been to establish what, if any, physical, chemical or biological effects may have resulted from a given installation. These studies typically compared existing conditions near the coastal generating station with sites some distance away considered as controls. This method was chosen because beforehand data are usually not available or are inadequate to provide useful comparisons. Sometimes gradients in parameters can be demonstrated that center on a thermal discharge and provide convincing evidence of an effect.

Discharges into open coastal waters through long outfalls usually produce extremely limited effects on benthic communities. Thus the influence of the San Onofre nuclear generating station's discharge about 2,500 feet from shore was estimated to extend for distances of about 50 feet, representing reductions in seaweeds arising from turbidity effects. Where the cooling water discharge flows into water restricted by surrounding land masses (i.e., rivers, estuaries, harbors), some effects can be traced for distances of more than a thousand feet. Frequently other kinds of discharges (i.e., oil refineries, sewage disposal) in the vicinity of a thermal discharge can cause overlapping fields of influence and the precise cause of an observed anomaly may be difficult to assign when such long distances are involved.

There has been some research into toxicity effects from metallic ions in the discharge stream. (24) Concentrations of aluminum, copper, nickel, tin and zinc in three invertebrate species were compared for specimens from the discharge canal of the Morro Bay thermal electric plant and control animals from a nearby jetty. Results were somewhat variable but there was no clear indication of higher values among collections from the discharge canal. One possible instance of copper toxicity among abalone in Diablo Cove may have occurred following preliminary testing of the Diablo Canyon nuclear power plant's pumping system at this site.

Although the organism and ecosystem reactions to thermal effluents is a complex subject, there is a

fair degree of understanding and an ability to predict the consequences in broad terms and identify meaningful limits. Engineering design has been able to mitigate certain adverse developments, but it can be costly. Studies made for the Diablo Canyon nuclear power plant indicated an offshore diffuser system would cost \$58 million more than for a shoreline discharge. (25)

Siting Concepts

Most of the thermal electric generating capacity in California has been located at surface sites on the coastline to make use of the abundance of ocean water for cooling. The Legislature, while encouraging the use of nuclear energy, recognized the thermal power plant sites are a resource to be conserved and enhanced and in 1970 added Section 800, Division 1 of the Public Resources Code to sponsor research on new methods of power plant siting.

The Legislature appropriated funds to the Resources Agency to conduct the research into methods of power plant siting which offer potential for enhanced public benefits in location, operation and protection of the environment. The investigations were to include underground and underocean sites, manmade islands, power plant parks, the desirability of locations on or near tidal lagoons and other concepts which appeared attractive in minimizing the impact on the environment.

Studies carried out by the Resources Agency were conducted by the engineering firm of Holmes & Narver, Inc. and included 17 different concepts for nuclear power plants although several of those were only slight variations of others. (2) In evaluating the different concepts the investigations considered such factors as cost, environmental feasibility, and risk. The weighted values assigned to most of these factors is highly subjective making any ranking less than definitive. Had fossil fuel fired plants been included in the studies, other parameters would have added further complexity to any rating system. The relative costs of generation resulting from the selection of various concepts can probably be most reliably monetized.

Using data from the Holmes & Narver study, a cost comparison was made of three coastal site concepts less costly than inland siting and three coastal site concepts more costly than inland. The resulting cost of generation as an increase or decrease from inland siting is as follows:

Concept	Increase or Decrease in Cost (percent)
Inland	Base
Coastal - above ground	-8.2
Coastal - low profile	-8.1
Coastal - hillside	-4.9
Coastal - floating lagoon	+2.7
Coastal - underground	+6.2
Coastal - artificial island	+7.2

A study jointly sponsored by the Aerospace Corporation and the Environmental Quality Laboratory of the California Institute of Technology confirmed the feasibility of constructing large underground nuclear power plants. (14) The report of that study published in 1972 found that "... substantial improvement in containment is a reasonable expectation at many sites. The separation distance from the nuclear plant to population centers might well be reduced from the 10-20 miles characteristic of comparable surface plants to a small localized area. The greater safety implied by this containment might be utilized to permit siting closer to load centers or to locate sites where alternate surface sites are unavailable. The cost penalty associated with underground siting is estimated to be less than 10 percent and perhaps less than 5 percent of the total cost."

The optimum location of thermal electric power plants depends on many factors, including the type of plant to be built, compliance with governmental regulations, and economic feasibility. Although these factors act as major constraints to coastal siting, locations do exist that would make it possible to add generating capacity along the coastline.

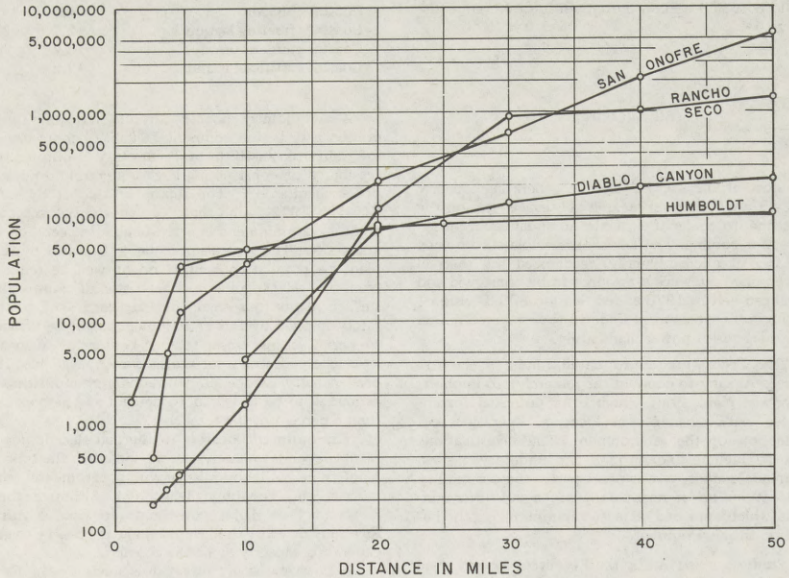
A coastline siting survey was made by the Environmental Quality Laboratory of the California Institute of Technology for nuclear power plants. This survey was reported in "Siting Nuclear Power Plants in California - The Near-Term Alternatives," July 1973. (3) One conclusion of that study was that of nearly 1,100 miles of California coast, 512 miles should be excluded for seismic reasons and 344 miles were considered too close to population. After excluding additional reaches for other reasons, there remained 52 miles of coast available for nuclear power plant construction.

In a Rand Corporation study for the State Assembly using a different methodology from the Environmental Quality Laboratory, it was concluded that 55 miles of coastline might be available for nuclear power plant siting. (26)

The Resources Agency/Holmes & Narver, Inc. studies concluded that nuclear power plants from a geologic standpoint could be sited on the surface along 144 miles of coastline but that if plant sites

could be excavated into the hillside, a total of 408 miles would be suitable. That study also concluded that approximately 100 miles of massive igneous or sedimentary rock coastline might be suitable for

underground siting of nuclear power plants. Restrictions due to population distance, conflicting land use and other specific site restrictions would reduce the suitable locations.



Source:
California Dept. of Public Health

POPULATION DENSITIES AROUND CALIFORNIA NUCLEAR POWER PLANTS

V. METHODS OF POWER PLANT COOLING

To meet the electrical load growth in California thermal-electric power plants, as in the rest of the United States, will produce an increasingly greater share of electricity. Steam that passes through the turbines must be condensed at the outlet side of the turbine in order to reduce the pressure and increase the power output. A condenser is used to lower the temperature and pressure of the steam and return it as condensate to the boiler where the cycle begins again. This is a closed system and little additional makeup water is needed.

In the process of cooling the condenser, large quantities of heat must be rejected to the earth's atmosphere where it passes through to outer space which is the ultimate heat sink. Several systems of heat transfer from the condensers are used although water is the common medium in each of the systems for transferring the heat. The methods used in these systems are once-through cooling, evaporative cooling, dry cooling, and combined wet-dry cooling.

Once-Through Cooling

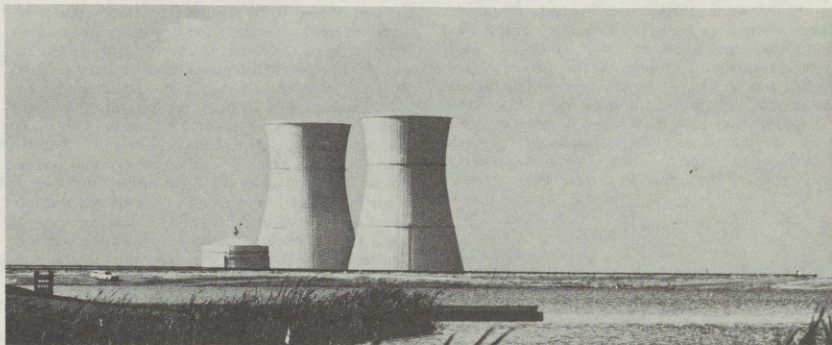
Once-through cooling is the most common method now in use for thermal-electric plants in the United States.⁽²⁷⁾ Cool water is taken from a stream, lake or ocean and is pumped through the condenser

where it picks up heat and then the warmed water is returned to the water body. Because of the temperature increase in the circulating water of about 20 degrees F, this type of system needs a large source of water. The heat returned to the source water eventually is dissipated to the atmosphere primarily through the process of radiation and evaporation. Where large bodies of water have been available this method of cooling has been preferred. The capital and operating costs are lower than for other types of systems and the efficiency is higher where cooler ocean water is available. There may be higher costs in the future for this type of system, however, if additional facilities are required to protect marine organisms.

Large quantities of water are required for effective condenser cooling. For a 1,000 MW generating unit, the continual flow of water through the system would be about 1,500 cubic feet per second. This is nearly equal to the flow in the Colorado River Aqueduct of the Metropolitan Water District.

Evaporative Cooling

In the evaporative cooling process, heat is removed from the condenser in the same manner as that used for once-through cooling; that is, by circulating cool water through the condenser. Heat is



Cooling towers of Sacramento Municipal Utility District's nuclear power plant at Rancho Seco high-

lights the Central Valley skyline near Sacramento. Cooling process requires a large supply of water.

removed from the water to the atmosphere largely by the evaporative process with the cooled supply being recirculated through the condenser. The water lost through evaporation must be replaced and this makes the evaporative system one of consumptive use. Several methods are used to bring the circulating condenser cooling water into contact with the air for maximum heat transfer. This is done by using natural draft cooling towers, mechanical draft cooling towers or cooling ponds.

Natural draft cooling towers depend on the upward flow of air as a natural draft through the tower to contact a spray of warm water falling inside the tower. Through this contact with the flow of air, evaporation occurs and cools the falling water which is recirculated through the condenser. As water vapor leaves the top of the tower it begins to cool and the condensate in the form of small droplets forms a visible plume which dissipates in the atmosphere. To overcome the kinetics of the system and to effectively cool the circulating water, natural draft towers may require heights in excess of 400 feet. Two towers would be required for each generating unit of approximately 1,000 megawatts of capacity.

Mechanical draft cooling towers are also part of a wet cooling system that uses a fan to force or induce a flow of air through the tower in contact with the spray of warm water which recirculates through the condenser after cooling. The cooling efficiency is about the same as for natural draft but there is some extra energy consumed in driving the fan. The height of these towers is usually less than 80 feet.

Cooling ponds consist of a body of water into which the warmed condenser coolant is pumped. There is a heat exchange on the surface of the pond through evaporation and radiation. The cooled water is then recirculated through the condenser. A large surface area is required for effective cooling because the cooling process can be quite slow. More rapid evaporation can take place when a spray system is used over the pond. Much less acreage is required with the spray system but there is a pumping cost and maintenance is higher than for the nonspray ponds.

Dry Cooling

The large requirement for a water supply for either once-through cooling or evaporative cooling has focused attention on using a dry system to accomplish the heat transfer. Dry cooling is a relatively new development with the largest installation being a 120 MW unit in England now being cooled by this method. Operating experience with this type of cooling is very limited.

The operating principle for dry cooling is similar to that of an automobile radiator. Water is circulated

through the condenser in a closed loop and the water is cooled by transferring the heat by conduction and convection from the metal fins of the heat exchanger or radiator. This may be inside a tower with mechanical draft creating an air flow to dissipate the heat to the atmosphere. No evaporation takes place and essentially no water is consumed. One limitation of a dry cooling tower is the ability to provide sufficient cooling within practical size to be effective during hot summer days experienced inland in California. Research and development of this type of system is being conducted.

Wet-Dry Cooling

The combination of evaporative cooling with dry cooling is receiving attention and study. It offers a means of reducing the consumption of water of a totally wet system and increasing the efficiency of a dry system where ambient air temperatures are high. Combined wet-dry cooling adds to the cost and complexity of the system and its economics has yet to be proven in large scale operation.

Cooling Water Consumption

The cooling water consumed by any of the evaporative systems is about the same, and consists of the water lost through evaporation and drift and the amount that is necessary to waste as blowdown. The amount of heat to be dissipated by evaporation is determined by the thermal efficiency of the plant which is the ratio of the electrical output to the energy input. ⁽⁴⁾ For fossil fuel plants the efficiency is 38 to 40 percent. Nuclear power plants are required for safety reasons to operate at less pressure than fossil fuel plants and have a thermal efficiency of about 32 percent. Nuclear power plants operate at less pressure than fossil fuel plants for safety reasons and this requires more heat to be taken out of the condenser. A fossil fuel plant is also able to dissipate out the flue about one-fifth of the heat to be rejected.

A type of nuclear reactor for which there is very limited experience in power generation is the high temperature gas-cooled reactor (HTGR). This type of unit rejects about 70 - 80 percent as much heat as the boiling water reactor, thus reducing the cooling water requirement.

There are several factors in the design and operation that govern the amount of water consumed by a particular type of power plant, fossil or nuclear. There appears to be no precise determination of the water quantity that will be consumed as there is a scarcity of operating data to cover all of the possible

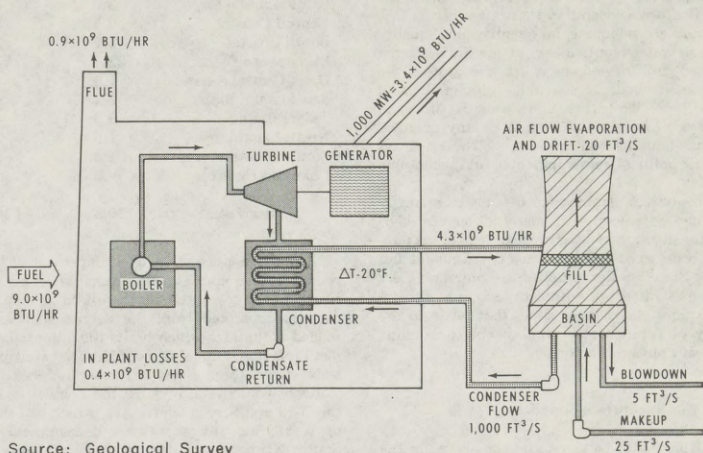
conditions under which a given power plant might operate. Most of the estimates available from different sources are based on calculated quantities with little prototype experience.

One of the major considerations in determining the water to be consumed is the mineral quality of the make-up supply and the allowable amount of dissolved minerals in the blow-down water from the cooling system. The more brackish the water supply, the more water that will be required. The waste discharge requirements for the point of disposal of the cooling system blow-down will affect the amount of mineral concentration in the circulating cooling water. Where disposal can be made to a salt sink the concentration can be higher with a lesser amount of water required than where disposal is to a stream affecting other beneficial uses.

Another factor affecting the consumption of water is the capacity factor or the number of hours during the year that a power plant will operate. Most estimates are based on a plant operating 75 - 80 percent of the time.

Climatic conditions at the power plant site will also influence the demand on the cooling system and the amount of cooling water consumed. This is not as significant as the water quality in determining the amount of water consumption.

Considering the many factors that govern the amount of water consumption it is not meaningful to make a precise determination for any given power plant and a range in values should be used. For a 1,000 megawatt thermal-electric power plant this range may be from about 14,000 acre-feet per year to over 25,000 acre-feet per year.



Source: Geological Survey
Circular 703

HEAT BALANCE DIAGRAM
TYPICAL 1000 MW FOSSIL-FUELED THERMAL-ELECTRIC PLANT

VI. WATER SUPPLY

California's water resources have been adequate to meet the growing needs of its population and to support its present economic development. In making an assessment of the availability of a water supply to satisfy the future demands of all beneficial uses, including power plant cooling, the nature, occurrence and location of water resources must be examined. California's water resources have been investigated and extensively developed over a long period of years and voluminous data have been compiled and assembled.

One of the conclusions of the California Water Plan adopted by the Legislature in 1959 was, "The waters originating in California, together with the rights of California in and to the waters of the Colorado River, are adequate in quantity and quality to satisfy all water requirements of the State after it has reached full development, if the waters are properly controlled, conserved, protected, and distributed."⁽²⁸⁾ While this conclusion is still valid from a physical standpoint, there are many practical reasons that limit its realization.⁽²⁹⁾ These reasons have legal, political, environmental and economic bases.

Water resources planning has become increasingly complex and interacts with many other considerations in the decision-making process. Numerous public policy issues exist that affect the development and use of the State's water supplies for which no clear guidelines exist. It is not within the scope of this report to explore all of these issues that relate to the availability of future water supplies but to examine the significant physical factors.

Surface Supplies

One of the major factors to be considered in the availability of water in California is that it occurs in the form of precipitation mostly in the winter and early spring months. Much of the runoff comes in brief periodic floods that move quickly to the ocean and are unavailable for later use unless reservoir storage is provided.

Maldistribution of the natural runoff is a major problem in utilizing the available resource. Only about 30 percent of the total stream flow occurs south of the latitude of Sacramento, while nearly 80 percent of the water demand occurs south of that line.

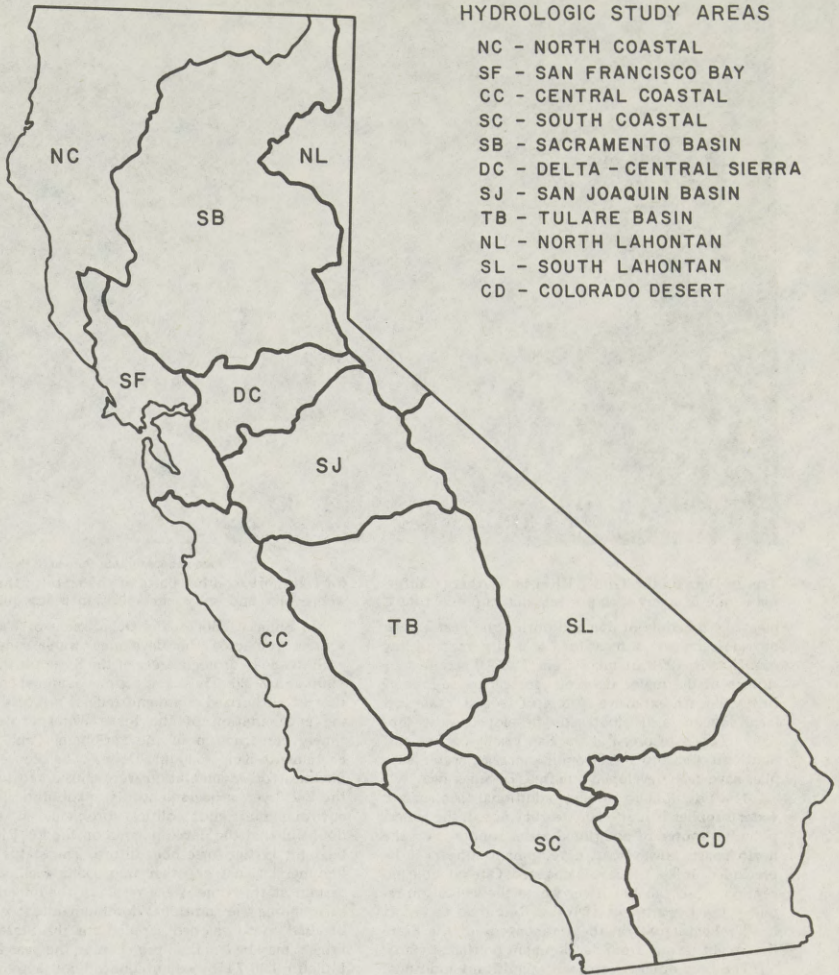
The total average water supply available to California is about 76.6 million acre-feet per year including inflow from Oregon of 1.4 million acre-feet and annual entitlement to the Colorado River of 4.4 million acre-feet. The distribution of the 70.8 million acre-feet runoff in the 11 hydrologic areas within the state is shown on the following table:

Average Annual Runoff from Hydrologic Area

Area	One Million Acre-Feet	Percent of Total
North Coastal	27.2	38.5
San Francisco Bay	3.0	4.2
Central Coastal	2.5	3.5
South Coastal	1.2	1.7
Sacramento Basin	22.4	31.6
Delta-Central Sierra	1.5	2.1
San Joaquin Basin	6.4	9.0
Tulare Basin	3.3	4.7
North Lahontan	1.8	2.6
South Lahontan	1.3	1.8
Colorado Desert	.2	.3
State Total	70.8	100.0

It may be noted that over 38 percent of the total runoff occurs in the north coastal area and flows in rivers trending to the northwest in deeply incised canyons separated from the Sacramento Valley by rugged mountains which limits the potential development of this source of supply. The availability of water from these rivers is further reduced by their status as wild rivers. In 1972 the Legislature enacted the Wild and Scenic Rivers Act, which had the effect of precluding any significant development on the Smith, Klamath, Trinity, Eel and Van Duzen Rivers of the north coast which account for about 25 percent of the total available water supply in the State.

Estimates made in reports by the Department of Water Resources indicate that about 60 percent of California's present water supply comes from regulation and diversions of the natural runoff from surface streams. The flow in some streams may vary from near zero in the late summer to many thousands of cubic feet per second during winter or spring floods. Over 1,200 dams have been constructed throughout the state to help regulate this runoff and make it usable as a firm water supply. Regulation is required to



Source: Department of Water Resources
 Bulletin No. 160-74
 "The California Water Plan
 Outlook in 1974"

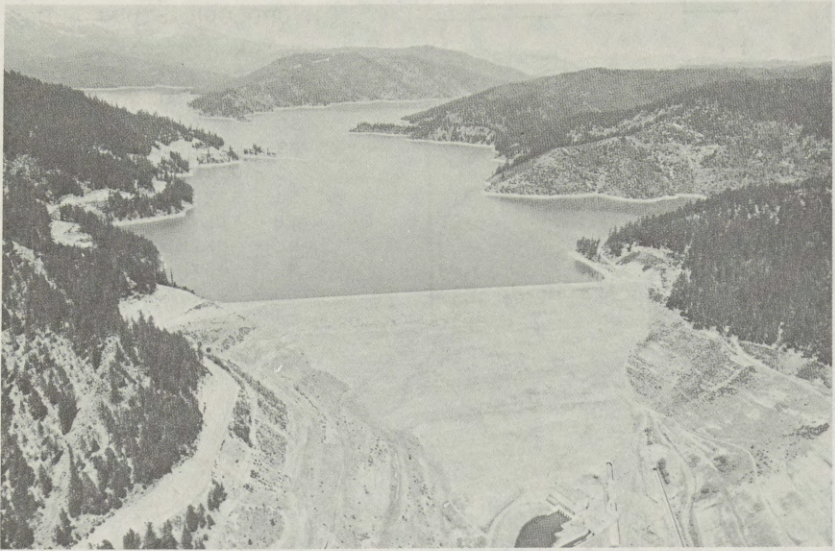


Photo courtesy U.S. Bureau of Reclamation.

Trinity Dam on the Trinity River in Northern California is one of many such projects that conserve runoff

meet the schedule of demand during the year and to provide carryover storage for use in dry years of low runoff as in 1976. It takes from 7 to 10 acre-feet of storage in the major reservoirs for each acre-foot of firm yield. An extensive system of federal, State and local aqueducts distributes the developed water supplies to areas of use. For the San Francisco Bay and Southern California metropolitan areas, water supplies have been developed hundreds of miles away.

The potential to develop additional firm surface water supplies is limited. As earlier noted, the largest potential source of additional water supply is on the north coast; however, its development appears to be precluded unless the law is changed. One possible exception is on the Eel River where the legislation requires the Department of Water Resources to report to the Legislature on the water needs of the State that might be met from development on that stream.

The only other streams with significant additional development opportunities are in the Sacramento Valley. Several tributaries of the Sacramento River could yield limited additional firm water supplies if regulatory reservoirs are constructed but such developments would be costly.

for transport to other parts of the state to the south where rain and snow precipitation is less plentiful.

In Bulletin 160-74, the Department of Water Resources projected the developed water supplies in each of the hydrologic areas of the State for the years 1990 and 2020. These projections assumed construction of authorized State and federal projects including augmentation of the State Water Project and timely construction of the Peripheral Canal in the Sacramento-San Joaquin Delta. The conservation facilities for augmentation were considered to be on the Eel River or Sacramento River tributaries. Due to environmental and political problems, it appears doubtful that the developments on the Eel River will be built in the foreseeable future. The status of the Peripheral Canal or other trans-Delta facility is uncertain at this time. As a result of the uncertainties surrounding the additional developments, it is probable that the developed supplies for the State Water Project may be less than projected in the year 2000 in Bulletin 160-74 by about one million acre-feet per year. Timely construction of the Peripheral Canal is necessary to prevent additional deficiencies in supply. The developed supplies projected to be available assuming construction of authorized federal and State projects were derived from Department of Water



Photo courtesy California Department of Water Resources. Aerial view shows San Joaquin-Sacramento Delta area through which proposed Peripheral Canal is planned.

Resources data in Bulletin 160-74. These supplies assume completion of presently authorized federal and State projects and include safe ground water yield and some wastewater reclamation. The projected developed water supplies are shown on the following table:

Projected Developed Water Supplies				
Hydrologic Area	1980	1990	2000	
North Coastal	950	960	970	
San Francisco Bay	1,450	1,690	1,770	
Central Coastal	870	950	950	
South Coastal	3,640	3,640	3,910	
Sacramento Basin	5,970	6,510	6,670	
Delta-Central Sierra	2,340	2,590	2,660	
San Joaquin Basin	4,590	4,840	4,840	
Tulare Basin	7,090	7,260	7,290	
North Lahontan	410	430	440	
South Lahontan	320	320	320	
Colorado Desert	4,070	4,130	4,140	
State Total	31,700	33,320	33,960	

Ground Water

Ground water can be obtained from alluvial deposits in many areas of California. About 40 percent of the applied water requirement is now pumped from ground water basins. (30) The safe yield of these basins is maintained when percolation and inflow is equal to extractions. This is not the case for many basins in California as an overdraft is occurring at the present time of about 2.2 million acre-feet per year.

The only major ground water basin that has the capability of a safe yield greater than its present use is in the Sacramento Valley. No estimate has been made of the additional firm water supply that could be developed from ground water in the Sacramento Valley although studies now being conducted by the U.S. Geological Survey and the Department of Water Resources should provide this information when they are completed.

The San Joaquin Valley now has a ground water overdraft of about 1.5 million acre-feet per year. This overdraft is causing a drop in the ground water levels that has caused some areas to experience a decline of as much as 100 feet or more during the past decade. The lowering ground water levels causes increased economic cost for well and pump modification and increased consumption of electricity for pumping. Land subsidence is also occurring in the areas of overdraft. This subsidence extends over hundreds of thousands of acres with a ground lowering of from 1 to 20 feet or more.

One method of extending the available ground water supply is through conjunctive operation of ground water basins with a surface supply. This is now being done in many of the principal ground water areas in the State. Under this concept of operation, ground water levels are raised and lowered by recharging in wet years and withdrawing in dry years when surface supplies are deficient. The potential for conjunctive operation has its limitations due to limited availability of water supplies and geologically feasible recharge areas to percolate the water. There must also be available conveyance systems to get the water to the recharge areas and wells and pumping equipment to extract the water when needed.

Some of the more favorable areas for recharging with imported water supplies are the Santa Clara Valley, eastern San Joaquin Valley, and the San Fernando, San Gabriel and Chino basins in Southern California. The potential in all of these basins is limited by some of the constraints mentioned above.

VII. WASTE WATER AS A SOURCE OF COOLING WATER

Waste water offers a potential to reduce the demand on fresh water supplies for evaporative cooling, however, it must be viewed from the perspective of some limitations.

Waste water reclamation is one of the more promising supplemental sources to meet California's water supply needs. An accepted definition of waste water reclamation is the planned renovation of waste water with the intent of producing usable water for a specific beneficial purpose.⁽³¹⁾ Reclamation may benefit an existing supply by improving its water quality or it may create a "new" supply by making usable waste water that is being discharged to saline water. It is the latter that is a more significant potential for power plant cooling.

Much of the water used in California is returned after use to make up part of the fresh water supply, either directly after use or following treatment. This includes 90 percent of the irrigation return flows from 9 million acres of irrigated land and the treated sewage effluent from the municipalities of the Sacramento and San Joaquin valleys.

There are two main sources of waste water whose reuse would constitute "new" water. These sources are agricultural drainage water that is degraded to the point that it can no longer be reused and must be removed from the area, and municipal and industrial waste water that is discharged into the ocean and its estuaries.^(32,33)

Not all waste water produced can be reclaimed and reused. The amount that can be reused is limited by:

- (a) Quality of the waste water.
- (b) Cost of treatment.
- (c) Cost of conveyance and distribution in the area where it will be used.
- (d) Price that users are willing to pay.
- (e) Need to leave sufficient flow to transport waste residues to a disposal site.

Agricultural Waste Water

Agricultural waste water is water which can no longer be beneficially used in farming practices. It is drainage water that is not reusable for irrigation because of excessive concentrations of dissolved minerals. In the growth of a plant, pure water is taken from the soil and evaporated from the leaves through the process of evapo-transpiration. The minerals con-

tained in the applied water accumulate in the soil and unless removed from the root zone, will concentrate and cause damage to the plant.

The accumulated salts are removed by drainage water moving below the root zone and flowing to a salt sink. The quantity of drainage is largely determined by the quality of the irrigation water and the amount of salts to be leached from the soil within the root zone. The ocean is a natural salt sink where the irrigation drainage, or return flows, commingle with the streams flowing to the ocean. Other major sinks where normal flow to the ocean does not occur and where salts are being concentrated inland are the Salton Sea in the Imperial and Coachella Valleys, Tulare Lake Basin in the San Joaquin Valley, and Owens Lake in Inyo County.

The San Joaquin Valley faces a growing problem of salt management that threatens the agricultural economy of the area.⁽³⁴⁾ Extensive studies made over the past decade by the Department of Water Resources and others have resulted in recommending the removal of brackish drainage water by a master drain system discharging into San Francisco Bay. Such a drainage system was authorized in the Burns-Porter Act of 1959 as a part of the State Water Project. Because of problems of repayment the State has not commenced its construction. The facility as authorized would ultimately extend from near Bakersfield to the Sacramento-San Joaquin Delta.

The U.S. Bureau of Reclamation has commenced construction of the San Luis Interceptor Drain, authorized as a part of the San Luis Act in 1960. This drainage canal is authorized to extend from near Tulare Lake northward to the Delta. About 75 percent of the facility is constructed from the southerly end to a Kesterson Reservoir, near Gustine. It will constitute part of a master drain system for the valley.

The quantity of drainage water that will be generated in the San Joaquin Valley has been estimated by an Interagency Drainage Program being conducted by the Bureau of Reclamation, Department of Water Resources and State Water Resources Control Board.⁽³⁵⁾ Recent estimates indicate that drainage problems exist for about 1.8 million acres in the valley, with potential problem areas of an additional 2.6 million acres. The Interagency Drainage Program predicted the average annual volume of agricultural drainage water to be produced in the San Joaquin Valley as follows:

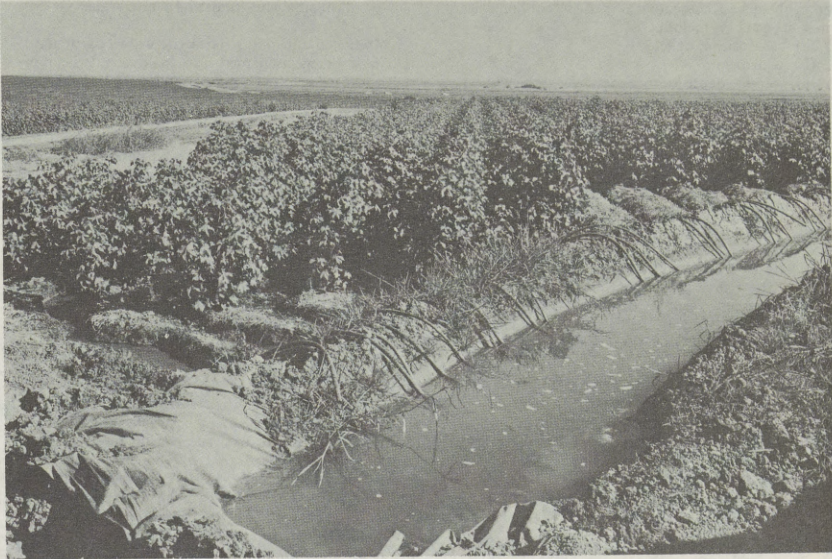


Photo courtesy U.S. Bureau of Reclamation.

Crop irrigation in the San Joaquin Valley, as above, provides valuable food and fiber production, but has

1980	125,000 acre-feet
1990	280,000 acre feet
2000	440,000 acre-feet

From the magnitude of the estimated quantities of drainage water that will need to be managed, it appears that this source offers considerable potential for a cooling water supply. There are limitations, however, that will reduce the practicality of this source. Institutional, financial and economic constraints will probably reduce the actual quantity of water available in the drain from the theoretical estimates.

The brackish drainage water that must be removed in time from the San Joaquin Valley lies at a depth of 6 to 10 feet below the surface of lands scattered over nearly 2,800 square miles. This will require the construction of on-farm drains, collector drains and a master drain facility. In 1974 the capitalized costs of these works was estimated by the Department of Water Resources to be about \$470 million. Over two-thirds of the cost would be for on-farm systems requiring individual financing and construction.

The expenditure of the required amount of money will be slow and the institutional arrangements for

led to wastewater management problem. Power plant cooling use is proposed as a partial solution.

financing, constructing and operating the systems have yet to be developed. There will probably be staged development using evaporation ponds in the Tulare Lake Basin for many years and gradual increase in flows into the federal San Luis Drain. Installation of on-farm systems is inhibited by a lack of facilities to receive the drainage water and transport it to the salt sink. The Interagency Drainage Program is addressing the overall problem of waste water management in the Valley. The Environmental Protection Agency requirements for waste discharge control under the Federal Water Pollution Control Act (PL 92-500) may provide a mechanism to help implement a waste management program.

An additional constraint to the use of agricultural waste water is one of water quality. The quality of the drainage water from tile drains will vary throughout the San Joaquin Valley and the dissolved minerals will change over time as the salts in the soil are leached. It is estimated that the total dissolved solids going into the master drain will begin at about 7,000 mg/l and reduce to about 3,000 mg/l by the year 2000. The drainage water will also be high in nitrates.

The problems associated with its use as cooling water, due to its quality, include:

- (a) Deposition of scale
- (b) Corrosion
- (c) Sludge deposition
- (d) Accumulation of organic films and microbial growth
- (e) Algal growths

Irrigation drainage in the Palo Verde, Coachella and Imperial Valleys constitutes another potential source of cooling water. There is now about 400,000 acre-feet per year of irrigation drainage water that returns to the Colorado River from the Palo Verde Valley. This water has a salinity of from 1,900-2,000 mg/l. The Coachella and Imperial Valleys are separated by the Salton Sea, which is a natural salt sink 30 miles long and from 10 to 15 miles wide with an average depth of 30 feet. The water surface elevation of the Salton Sea has risen because of irrigation drainage from 250 feet below sea level in 1925 to its current elevation of 230 feet below sea level where it has fairly stabilized.

The average annual inflow to the Salton Sea was 1,315,000 acre-feet between 1965 and 1970 with approximately one million acre-feet from irrigation return flows. (36) The inflow and its sources are as follows:

Source	Acre-Feet/Year
Republic of Mexico	107,000
Imperial Valley irrigation returns	996,000
Imperial Valley communities	8,000
Coachella Valley irrigation returns	99,000
Coachella Valley communities	5,000
Natural runoff and seepage	100,000
Total	1,315,000

Drainage in the Imperial Valley flows northward into the Salton Sea through the New and Alamo Rivers. These rivers cross the international boundary from Mexico and contain drainage from farmlands in the Mexicali Valley. The flow in the New River also contains sewage discharge from Mexicali, Mexico.

The mineral content (TDS) of the Alamo River is about 2,500 mg/l and that of the New River about 3,500 mg/l. The salinity of the Salton Sea is now about 38,000 mg/l TDS which is greater than the ocean. As salinity in the Salton Sea has increased, concern has been expressed that it will eventually eliminate fish life and create unfavorable conditions for recreational and seashore development. A number of studies have been conducted by state and federal agencies to determine a feasible plan to control the salinity in the Salton Sea. No plan of action has yet been authorized to control the salinity.

Municipal and Industrial Waste Water

Municipal and industrial waste water, particularly that now being discharged into the ocean, is a potential source for power plant cooling. As the urban areas have grown, larger quantities of waste water have been collected and conveyed to central locations for treatment and have become more readily available for reclamation. Approximately 2.5 million acre-feet of municipal waste water is now processed each year.

Municipal and industrial waste water discharged in the Central Valley area of California is now either reused as a part of the water supply or contributes to the outflow from the Sacramento-San Joaquin Delta, providing the same function as the natural tributary flow in maintaining salinity levels in the Delta. Other municipal and industrial waste water now discharged to salt water that could be reclaimed would be a "new" source of supply.

The quality of municipal waste water reflects the initial mineral quality of the water supply entering the system and the contributions added during use. The mineral quality of the waste water varies throughout the state but, as an average, the sewage effluent has a TDS content of about 300-500 mg/l greater than the supply water. The mineral content is not changed in normal treatment processes. Where the water supply comes from the Colorado River, the sewage effluent has a TDS content of about 1,100 mg/l. In the San Francisco Bay area, a study conducted by several state and local agencies showed the waste water had an average salinity of about 1,000 mg/l. This high salinity is despite the fact that the major source of water supply to the area is imported from Sierra Nevada streams with a TDS content of about 40 mg/l.

The municipal waste discharges are collected from throughout the metropolitan areas and conveyed to the point of treatment and disposal. Unless power plants could be located at the point of disposal, usually near the ocean, long conveyance and pumping facilities for the treated waste water would need to be constructed to locations where the plants would be built. Just as the electrical load center is near the coastline, the municipal waste water is also located near the coastline.

One potential source of municipal waste water that has recently been considered for power plant cooling is the sewage effluent from the Sacramento metropolitan area. It could be conveyed to the Rancho Seco Unit No. 2 site of the Sacramento Municipal Utility District (SMUD), about 25 miles southeast of Sacramento. In its Environmental Impact Report, SMUD rejected municipal waste water as a viable source in favor of Folsom South Canal from the American River for a number of reasons. (37) Some of these reasons were:

- (a) Additional water treatment beyond secondary treatment would be required to reduce the nutrients to prevent biological growths.
- (b) The hardness of TDS would cause scale and corrosion and would degrade the blowdown from the cooling towers so that disposal of the waste would be difficult.
- (c) During power plant shutdown, the reduction in demand for makeup water would require the discharge of that water from the regional treatment plant with the rest of the excess waste water.
- (d) The cost of conveying and treating the municipal waste water at 80 percent plant capacity factor would be \$358 per acre-foot compared to the cost of Folsom South Canal water at \$16 per acre-foot.

Treatment of Waste Water

In order that waste water be usable as a source of makeup water for power plant cooling, extensive and costly additional treatment is usually required. The nutrients cause algal and other biological growths in cooling towers and ponds and the dissolved minerals cause scale and corrosion in the equipment.

As evaporation takes place, there is a concentrating of the minerals in the circulating cooling water. This requires a continuous discharge or blowdown of the circulating water to carry off the minerals. The amount of blowdown depends on the quality of the makeup supply and the amount of concentration that can occur.

The pretreatment process of the waste water supply depends on the quantity and quality available. The poorer the quality, the fewer concentrations that can be achieved and the more water required in the cooling process due to more water discharged as blowdown. Most of the agricultural and municipal waste water that is available in California would require biological treatment for removal of nitrogen, softening, and demineralization. This includes the more brackish waste waters of the San Joaquin and Imperial Valleys and some major municipal waste water sources.

Although the biological treatment and softening processes are costly, the technology is known and these processes have been used for many years. Demineralization of large volumes of water is still an

evolving and expensive technology. The Department of Water Resources has extensively investigated the application of saline water conversion in the management of brackish and waste water supplies. This work has been carried on near Firebaugh in the San Joaquin Valley with the application to agricultural drainage water. To study the feasibility of using agricultural drainage water in the southern San Joaquin Valley for power plant cooling, an investigation is currently being conducted cooperatively by the Department of Water Resources, University of California, Electrical Power Research Institute, Los Angeles Department of Water and Power, Pacific Gas & Electric Company and Southern California Edison Company.

The cooperative agricultural waste water study involves the construction of a pilot treatment plant that will include all of the processes from raw water intake through cooling tower operation and blowdown. The processes will include softening all of the supply with ion exchange. The plant will be installed in the vicinity of the available drainage water. The blowdown from the plant will be distilled using a vertical tube evaporation (VTE) process. The desalted product water from the blowdown will be mixed with the cooling makeup water so that there can be 20-25 concentrations. The makeup water will have a TDS content of from 3,000-6,000 mg/l. The cost of treatment should also be determined by the study.

In all of the water treatment processes now in use and under investigation for power plant cooling, large quantities of brine and sludge remain for disposal. The quality of the blowdown water must also meet the waste discharge requirement of the Regional Water Quality Control Boards. (38) When discharge is to a natural stream channel, the quality of the blowdown must be better than if it goes to a drain with conveyance to a salt sink. Where drainage facilities are not available, the blowdown is ponded and held at the site. Solar evaporation ponds are used to concentrate the brine and must be adequately constructed to prevent leakage that would pollute the ground water or surface water. Sludge and other wastes from the softening and biological treatment processes must receive adequate disposal.

The conveyance of waste water to power plant sites, its satisfactory treatment for condenser cooling, and the disposal of brine and sludge make many waste waters an expensive source of cooling water. There will also be additional energy costs to its use, particularly where demineralization is required.

VIII. DEMANDS FOR WATER

The quantity of fresh water used for thermal power plant cooling has not been significant in California. In the future if power plants are sited inland to meet the electrical load growth, the consumptive water demand will be of considerable magnitude. The availability of a water supply to meet this demand must also be viewed in the context of other beneficial uses that are also increasing. Estimates of growth of demand for water, like electricity, is fraught with many uncertainties, nevertheless, procedures have been employed by the Department of Water Resources that provide a reasonable range of possibilities.

The predominant factor in estimating most future water demands is population growth. The urban demand for water, as well as agricultural production and its accompanying demand, has population as the basis of future estimates. In Bulletin 160-74, the Department of Water Resources used a set of alternative futures based primarily on different population growth factors as provided by the California Department of Finance. These factors include fertility rates which make up the different population series of the U.S. Bureau of Census. These series when combined with varying net migration rates determined the population growth.

As with electricity demand, no one action or future condition of itself will significantly influence water demand, although the aggregate of a number of events, small in themselves, may be significant. No one alternative future represents the most probable future. Alternative future III is reasonable in evaluating actions to meet water demands and is consistent with the efforts being made to slow the rate of electricity growth.

The applied water demands are the quantities required to be delivered to the point of use, such as to municipal water systems or to the lands to be irrigated and are larger than the net water demand. Net water demand results from decreasing the applied demand to account for internal reuse of water, drainage to provide salt balance in irrigated areas and conveyance and other losses to places of use. For the state as a whole, the net demands are about 17 percent less than the applied.

Urban Water Use

Urban water demands include residential, commercial and industrial uses and now account for about 15 percent of the total water use in California. Residential use accounts for about 68 percent of the urban use. A number of factors affect the per capita use of water, including climate, price of water, economic level, and family size and type of dwelling. Trends in per capita use have increased historically, although there is now some leveling off, particularly in the South Coastal area.

As available water supplies have become more scarce in certain areas, emphasis on water conservation is receiving more attention. This should have the effect of reducing the rate of growth of urban water demand, particularly in communities that face critical shortages in drought years, although the net effectiveness statewide is not known.

The projected urban applied water demands in each of the hydrologic study areas are shown in the

Alternative Future	Population Series	Fertility Rate	Net Migration	Population (in millions)		
				1980	1990	2000
I	C	2.8	150,000	23.0	27.4	31.9
II	D	2.5	150,000	22.8	26.7	30.5
III	D	2.5	100,000	22.7	26.1	29.3
IV	E	2.1	0	21.9	23.6	24.7

following table:

Area	Demand in 1,000 Acre-Feet		
	1972	1980	2000
North Coastal	99	101	113
San Francisco Bay	1,096	1,430	1,605
Central Coastal	200	289	324
South Coastal	2,624	2,980	3,345
Sacramento Basin	520	674	756
Delta-Central Sierra	192	239	268
San Joaquin Basin	213	279	313
Tulare Basin	402	471	528
North Lahontan	25	39	43
South Lahontan	99	136	152
Colorado Desert	110	139	153
Total	5,580	6,777	7,600

Agricultural Water Use

Irrigated agriculture, which now uses about 85 percent of the water, is California's number one productive industry, accounting in 1975 for over \$8 billion in direct receipts. Agriculture-related industries, including food processing and sales of equipment and supplies, generated additional income of over \$20 billion. The industry has faced a number of marketing and financing problems, as has agriculture elsewhere. However, the stability of climate and water supply has given California a major role in national and foreign markets.

Projecting future acreage for irrigated agriculture requires assumptions about several factors that influence the demand for food and fiber. The major factors are national population growth, per capita consumption, changes in crop yield, foreign trade policies, and California's relative share of the national production.

At the present time, there are approximately 9 million acres of irrigated land in California. Expansion of irrigated agriculture has taken place to meet the growing local, national and foreign demands for food and fiber. As urbanization has taken place, irrigated land has been encroached upon at a rate of from 20-25,000 acres per year. This has caused a dislocation in irrigated area as new lands have been brought into production, primarily in the San Joaquin Valley, to offset the reduction near the urban areas.

The problems associated with higher energy costs, limitations on use of chemicals, competition from other states, and higher costs of water supplies will have the effect of slowing the demand for water. In projecting the water demand for agriculture, alternative future III of Bulletin 160-74 was used, reflecting the U.S. Population Series D and a lower foreign trade level than that of recent years.

The 1972 and projected irrigated land area is as follows:

1972	8.8 million acres
1980	9.1 million acres
1990	9.4 million acres
2000	9.6 million acres

Some opportunity exists for less water consump-



Photo courtesy U.S. Bureau of Reclamation.

Irrigated agriculture is by far the greatest water user in California—consuming about 85 percent of the sup-

ply. Agriculture is the state's most productive industry—\$8 billion in direct receipts recorded in 1975.



Photo courtesy U.S. Bureau of Reclamation.

Improved irrigation methods will provide small overall use reduction since return flows will be reduced.

tion by irrigated crops by increasing the efficiency of application. The use of small sprinklers and drip irrigation will have greater application in the future. Reduction in applied water, however, will result in a reduction of return flow that is a part of the supply for downstream users and percolation to ground water. The overall savings from more reduced application will probably be relatively small in comparison to total consumption.

The projected net demands for urban and agricultural water derived from Bulletin 160-74 are shown on the following table:

Area	Applied Water Demands for Agriculture in 1,000 Acre-Feet		
	1980	1990	2000
North Coastal	710	710	710
San Francisco Bay	270	290	300
Central Coastal	1,090	1,190	1,210
South Coastal	830	720	650
Sacramento Basin	6,470	7,050	7,210
Delta-Central Sierra	2,620	2,810	2,960
San Joaquin Basin	5,710	6,040	6,090
Tulare Basin	11,270	11,750	11,950
North Lahontan	420	430	430
South Lahontan	300	300	290
Colorado Desert	3,220	3,320	3,320
Total	32,910	34,610	35,120

Net Demand for Urban and Agricultural Water

The net water demand is less than the amount of applied water and accounts for reuse within the basin due to ground water recharge or redirection of return flows for downstream areas. The net water demand, as a percentage of the applied water demand, varies by different hydrologic areas according to the characteristics of the basin. Where ground water recharge is possible and little outflow occurs, the net demand may be about two-thirds of the applied demand. In the metropolitan areas where most of the excess in the form of sewage effluent is discharged into saline water, the net demand and applied demand are the same.

The projected net demands for urban and agricultural water derived from Bulletin 160-74 are shown on the following table:

Area	Projected Net Water Demands for Urban and Agricultural Use (1,000 Acre-Feet)		
	1980	1990	2000
North Coastal	670	680	690
San Francisco Bay	1,450	1,720	1,890
Central Coastal	1,060	1,180	1,250
South Coastal	3,390	3,610	3,910
Sacramento Basin	6,040	6,640	6,840
Delta-Central Sierra	2,490	2,690	2,880
San Joaquin Basin	4,750	5,060	5,140
Tulare Basin	7,870	8,240	8,420
North Lahontan	430	440	450
South Lahontan	300	310	340
Colorado Desert	4,050	4,090	4,120
Total	32,500	34,660	35,930

In-Stream Uses

The value of in-stream water use has received increasing recognition in recent years. Although the benefits from in-stream uses are difficult to quantify, they are important considerations in the planning and decision-making processes. Such uses include live stream maintenance for aesthetics, recreation, and fishery purposes. Minimum flows to maintain water quality conditions may be included. In the Sacramento and San Joaquin Rivers, natural flow, plus releases from storage reservoirs, is used for water quality management and salinity control in the Delta.

The magnitude of these water demands has a major impact on the availability of water to meet other intended uses. Recent water rights decisions of the State Water Resources Control Board have brought the issue of competing demands into sharp focus.

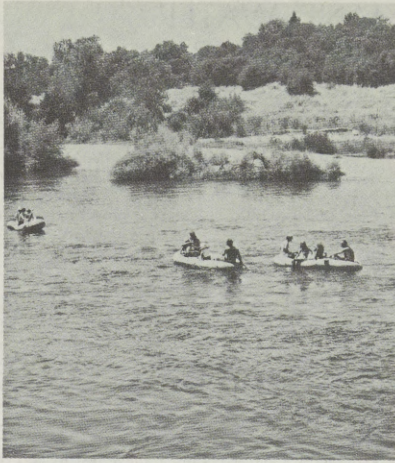


Photo courtesy California Department of Water Resources

Rafters demonstrate recreational enhancement from stored water releases on the lower American River.

In 1971, the SWRCB issued Decision 1379 relating to water quality in the Sacramento-San Joaquin Delta. This decision, although stayed by the courts, affects the firm water supply for the Central Valley Project and State Water Project by requiring greater fresh water outflows, including the release of water from reservoirs, than had been planned. The water quality standards that control are for the enhancement of fish and wildlife. As the decision stands, the loss of yield to the two projects is about 1.8 million per acre-foot. The final outcome of this decision is uncertain, as the SWRCB will reopen hearings and may consider some relaxation in dry and critical water years.

In another decision (D-1400), in 1972, the SWRCB required greater minimum flow in the American River than had been intended when the projects were authorized by Congress. The increased requirement of about 750,000 acre-feet per year imposed a substantial reduction in the amount of the firm water supply available for diversion into the Folsom-South Canal.

In Bulletin 160-74, the Department of Water Re-

sources estimated that the fish, wildlife and recreation water demands would total about 800,000 acre-feet statewide. This assumes that some of the flows that would provide in-stream uses would also be available downstream to be diverted or to meet other uses, such as on the American River.

The demand to provide salinity control and fishery enhancement in the Delta is the major in-stream requirement in the Central Valley that is not available for further beneficial use. Based on the SWRCB Decision 1379, an outflow of 3.4 million acre-feet is required to meet the salinity requirement.

Cooling Water Use

The consumptive cooling water requirement for thermal electric plants will depend on the extent to which they will be sited inland in California and the type and size of plant constructed. The estimated installed capacity to meet the electrical load growth was shown earlier in the report. The amount of that capacity that might be furnished by out-of-state sources and the mode of generation were determined from reports of the California Public Utilities Commission and from other sources.

The installed capacity that could require a consumptive cooling water supply if once-through cooling on the coast is not available is projected as follows:

Mode	Additional Capacity to be Installed Requiring a Cooling Water Supply (Megawatts)	
	1980-1990	1990-2000
Fossil	5,870	7,000
Nuclear	9,650	22,890
Total	15,520	29,890

The additional annual consumptive cooling water supply that would need to be developed for inland siting of the above generating capacity would be about 287,000 acre-feet during the 1980's and another 588,000 acre-feet during the 1990's, for a total of 875,000 acre-feet per year by the year 2000. Should some of the out-of-state sources of power not materialize, nor all the planned conservation efforts be effective, the cooling water requirements could be greater.

IX. WATER DEMAND-WATER SUPPLY RELATIONSHIP

The water demand-water supply relationship is a dynamic condition which provides an assessment at one point in time of both water use and the status of availability of supply. Water demands now exceed the available supplies in some areas of the state. The ability to meet the continuing water demands from the state's water resources depends on how these resources are conserved, controlled and developed. This management of the resources includes regulation in surface reservoirs and operation of ground water basins to supply needs. It also includes control of water quality to satisfy the beneficial uses. Salt balance and drainage of agricultural lands and treatment and disposal or reuse of municipal and industrial waste water are included in total management.

The orderly and timely construction of authorized state and federal projects is required if the water supplies are to be available to meet the demands as planned. Extensive delays or stoppage of projects due to litigation or funding constraints will further cause an imbalance in the water demand-water supply relationship.

Some developed water supplies are not yet being fully used within the intended service areas. This may occur because the conveyance facilities have not been constructed or because contractual arrangements have not been made. The Central Valley Project has developed supplies in the Sacramento Valley that are in excess until the demand in that area develops. This excess of supply over demand in normal years is available in the Delta to provide water quality control and diversion by the State Water Project and other units of the Central Valley Project.

Even though a temporary surplus exists in one hydrologic area, there may also be a shortage in some part of the same area due to an inability to deliver water to that location or because it is contracted for by another service area.

Of the 11 hydrologic areas of the state, all but the North Coastal, North Lahontan, and Sacramento Basin will receive a part of their water supply from the Sacramento-San Joaquin Delta. As requirements for water increase in the future, there will be a con-

tinuing depletion of flow to the Delta and increased diversion from the Delta.

The difference between the net demands and the developed water supplies is either a deficiency or a surplus at a given point in time. The data derived from Bulletin 160-74 show that most of the hydrologic areas of the state are now deficient, and this deficiency will continue to increase in the future. The deficiency is supplied for the most part by ground water overdraft. A long-term consequence of overdrafting is increased economic cost for pumping. Other long-term adverse effects may be a depletion of the supply in basins with limited capacity or water quality degradation due to saline water intrusion.

The water demand-water supply relationship reflects the difference between the available supplies and the net water demands. This difference is the supplemental demand or deficiency and statewide will amount to about 2-1/4 million acre-feet by the year 2000 for urban and agricultural use. These deficiencies, shown on the following table, will be increased to the extent fresh water supplies are used for thermal-power plant cooling.

Hydrologic Area	Deficiency in Water Supply to Meet Urban & Agricultural Demand (1,000 acre-feet)		
	1980	1990	2000
North Coastal	0	0	0
San Francisco Bay	0	30	120
Central Coastal	190	230	300
South Coastal	0	0	0
Sacramento Basin	70	130	170
Delta-Central Sierra	150	100	200
San Joaquin Basin	160	220	300
Tulare Basin	780	980	1,130
North Lahontan	20	10	10
South Lahontan	0	0	0
Colorado Desert	0	0	0
Total	1,370	1,700	2,230

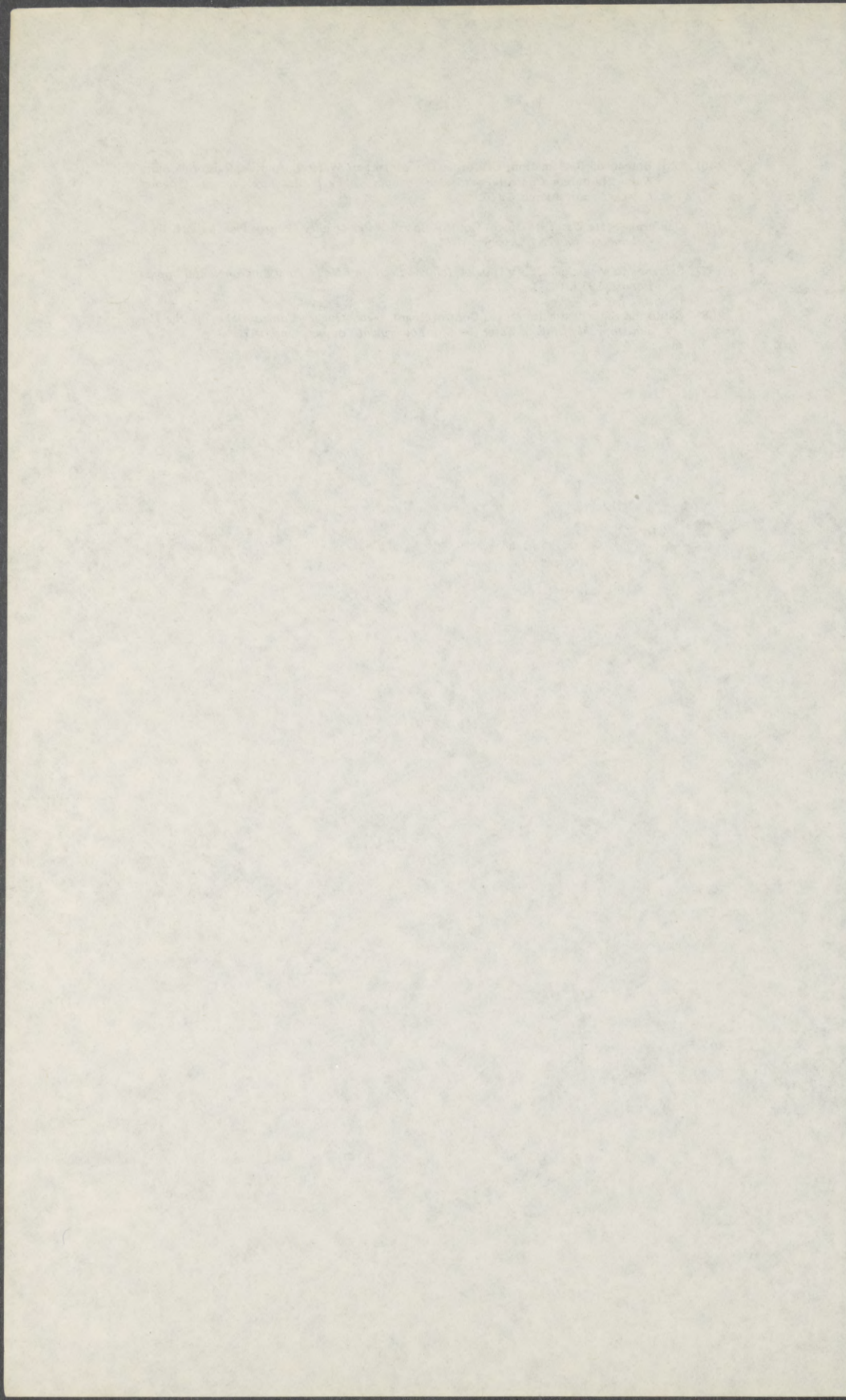
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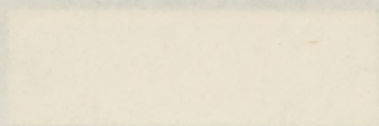
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