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ERDA LONG-RANGE PLAN AND PROGRAM

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HEARINGS BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND WATER RESOURCES OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE NINETY-FOURTH CONGRESS

SECOND SESSION

ON

AN IN-DEPTH EXAMINATION OF THE ENERGY RESEARCH,
DEVELOPMENT, AND DEMONSTRATION PLAN PROPOSED
BY ERDA

JULY 22, 28, 29, AND OCTOBER 1, 1976



Printed for the use of the
Committee on Interior and Insular Affairs

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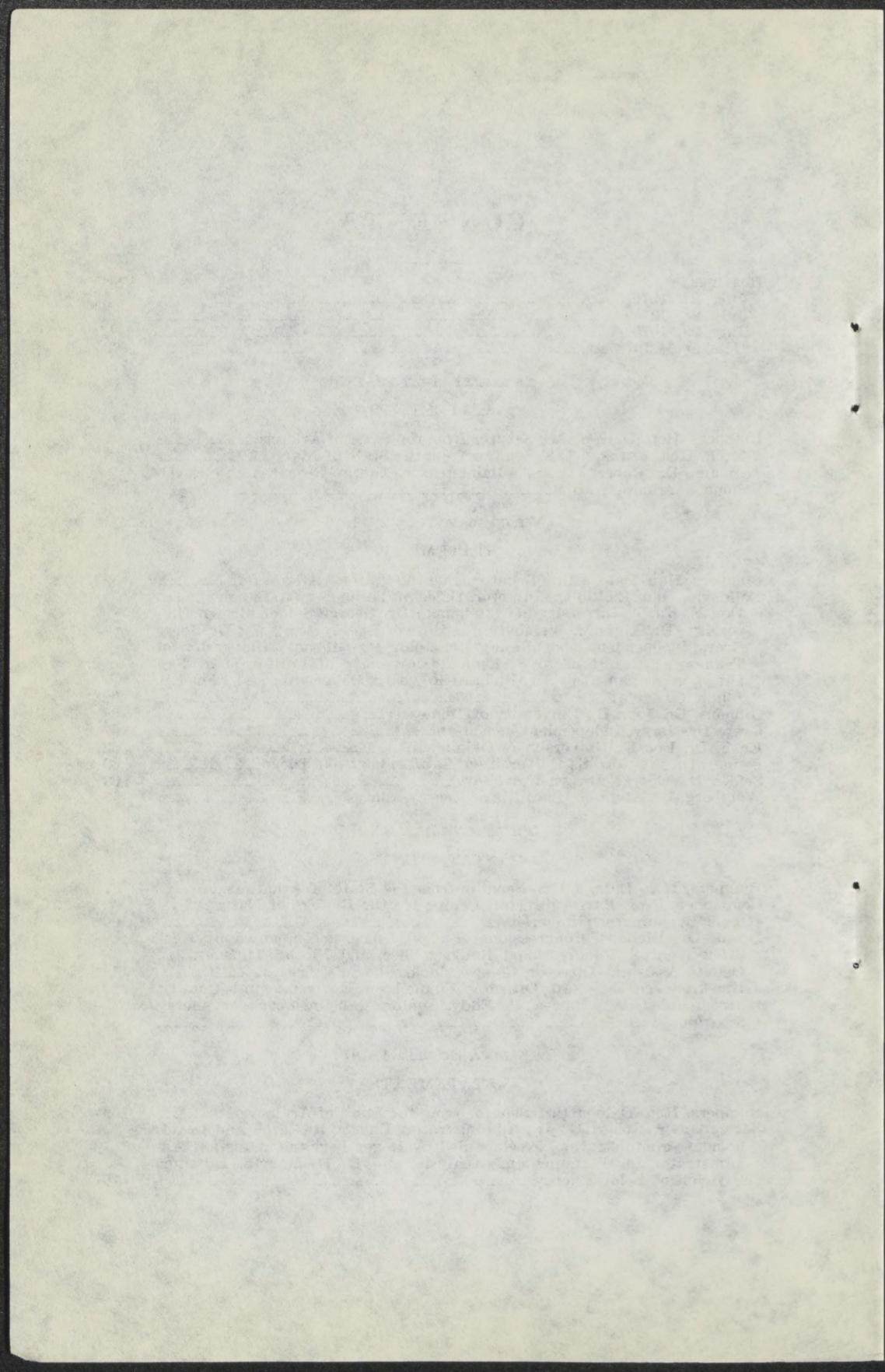
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ERDA LONG-RANGE PLAN AND PROGRAM

THURSDAY, JULY 22, 1976

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND WATER RESOURCES,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 3110, Dirksen Office Building, Hon. Dale Bumpers, presiding.

Present: Senators Bumpers, Church, Glenn, Fannin, Hatfield, and Moss.

Also present: Ben Yamagata, counsel; and Christopher Coccio, science consultant to the committee.

OPENING STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator BUMPERS. The subcommittee will come to order.

We are going to try to expedite these hearings this morning because we all have a very tight schedule.

This morning the Subcommittee on Energy Research and Water Resources begins an indepth examination of the energy research, development and demonstration plan prepared by ERDA and required by provisions of the Federal Nonnuclear Energy Research and Development Act. On July 28 and 29, this subcommittee will reconvene for 2 additional days of hearings during which testimony will be received from experts who have examined the plan submitted by the Energy Research and Development Administration. After we have received the testimony of our invited outside experts, then Dr. Seamans will be invited back a second time to discuss with us any findings we may have made about the plan.

Before we begin these hearings I think several facts should be highlighted to set the context within which this plan should be examined:

First. Foreign imports of crude oil are running at about 40 percent of our domestic needs. Prior to the 1973 embargo, 33 percent of our needs were supplied by foreign sources;

Second. In 1970 we paid about \$3 billion for foreign oil; in 1975, after a 500 percent increase in the price of oil, the cost soared to \$27 billion, and next year the cost may reach \$35 billion;

Third. In spite of the critical shortages caused by the OPEC embargo, we are actually importing a greater percentage of our oil from these less-than-reliable sources than we did at the time of the embargo.

Summarized, our appetite for energy has not been diminished by either higher prices nor greater dependence on foreign oil. The plain

and simple truth of the matter is that too many in this country exhibit too little concern for the fact that energy has become our Achilles' heel.

I firmly believe that we cannot dally in the job of building a domestic energy infrastructure which can translate our famed American know-how and ingenuity into an effective program for producing energy alternatives.

ERDA was created as a positive reaction to the energy crisis; ERDA was commissioned to spearhead the development of alternative sources of energy, be they greater or alternative supplies or more efficient uses of the supplies we now have.

The national plan for energy research, development and demonstration is the blueprint for that action. ERDA's view for developing energy alternatives; the rate at which that development will take place; the emphasis to be placed on different approaches; the near-term versus far-term impact of various energy options; all of these attitudes are embodied in this plan.

I am pleased to note that in drafting the second ERDA report on energy R. & D. the agency has placed greater emphasis on the unique opportunities for energy conservation. It is my belief that energy conservation is absolutely central to an effective national energy effort. Everyone—even the Ford administration—now agrees on this. To date, however, the full potential for saving energy, for using it more efficiently, remains substantially unfulfilled. And, to date, the national program to develop new conservation techniques has been pitifully weak in comparison to the lavish funding given exotic energy production technologies. Thus, while considering ERDA's budget request for fiscal year 1977, I am pleased to note that this committee reflected this same concern by increasing ERDA's poultry energy conservation budget by more than any other ERDA program.

It is my hope that these hearings will permit this subcommittee to examine other concerns which have been expressed about this energy plan. For example:

(1) The long-range plan is entitled "Creating Energy Choices for the Future," but for all the energy options under consideration, it appears to me that we are primarily examining different ways to create an all-electric society.

(2) Far too little emphasis, it would appear, has been placed upon an examination of energy systems versus particular energy technologies.

(3) This plan appears to rely on assumptions which bias the priorities of energy R. & D. toward high technology, capital-intensive supply alternatives.

(4) There is a gap between the priorities in this plan and the priorities exhibited in the annual ERDA budget. Examples are abundant: the plan states that enhanced oil and gas recovery will provide this nation with 10 years of time before a critical liquid fuel crunch is upon us, yet ERDA reduced their request for this program by \$6 million below last year's budget; ERDA raised conservation to a top priority in its up-dated plan, yet the funding request for fiscal year 1977 represented only a modest effort in this area.

If this plan is to be the pivotal point for this country's energy research, development and demonstration effort then the assumptions, priorities and goals expressed in the plan warrant scrupulous congressional oversight.

We are here to examine ERDA's plan; to make this plan the Nation's energy R. & D. plan.

Dr. Seamans, as we discussed yesterday, with your permission, we will introduce your statement in the record and then visit rather informally for something close to an hour, maybe it won't take that long. But in any event, Senator Church has another very pressing engagement on another committee and so I would like to allow him to make his opening statement at this time.

**STATEMENT OF HON. FRANK CHURCH, A U.S. SENATOR
FROM THE STATE OF IDAHO**

Senator CHURCH. Thank you very much, Senator. I just want to say that this hearing commences a series of hearings directed towards the future objectives of ERDA and the problem that the country faces, which is how to reverse the present trend of increasing oil imports. From the time that President Nixon first declared Project Independence, we have been losing that battle at a ruinous rate.

The establishment of ERDA was for the purpose of organizing governmental capabilities in a more efficient and effective way for the purposes of winning the battle and has yet to show any possible results.

While no decreases in oil imports have resulted, I recognize that ERDA has been established for only a short period of time and no one of this committee is expecting miracles, since it takes a while to get in gear. Nevertheless, the fact is that we are growing increasingly more dependent on foreign sources for our oil. The next embargo could be disastrous for this country, for we will have grown so much more dependent upon those sources since the last embargo, while we have talked about the energy crisis and how we are going to solve it.

It is incumbent upon this committee to commence to look ahead and ask those questions which will help us ascertain whether, in fact, we are making any progress at all, or just spending a lot of money.

And I think that is about as important a job as we have to do, Senator Bumpers, in exercising the general oversight responsibilities that fall to us. And so, let us proceed, without attempting to reach any judgment this morning, since it will take a good deal more penetrating inquiry than we have yet had an opportunity to conduct to reach any conclusions.

I think this is a commencement of a very important series of hearings and I want to thank Senator Bumpers for getting it started. And I know we will have our witnesses full cooperation this morning because I am certain he shares with us the desire to see this trend reversed which seems to be getting worse all the time.

We are both groping for the answer in the executive as well as the legislative branch. Thank you.

Senator BUMPERS. Thank you, Senator Church.

Incidentally, I might point out that we will have two additional hearings next week at which time we will bring in various experts to analyze ERDA's plan and make comments on it; following which you will be invited to come back and comment on their observations and criticisms.

Now, one of the things that the plan starts off discussing in the executive summary is, of course, the fact that we have become in-

creasingly dependent on foreign oil. That increasing dependence is not too difficult to analyze. It is due to two factors.

Of course, one, our own domestic consumption of petroleum has declined, and secondly, our energy appetites as we grow out of this past recession requires more energy. So as our appetite has grown and our own production has declined, it is quite necessary that we become more dependent on foreign products.

To suggest, as ERDA's national plan does that by 1985 we may reduce our dependence on foreign oil to 3 to 5 million barrels a day would still leave us dependent on foreign oil, unless there is an alternative plan in place such as the implementation of our national reserve policy act to the point that we would have enough reserves to carry us through such an embargo.

But one of the things that, of course, has been uppermost in my mind, is that ERDA and quite frankly the executive branch of Government starting with the White House has not really placed the emphasis on solving our problems, so far as energy dependence on foreign oil is concerned, in the proper perspective.

And to me the proper perspective is to say that we are wasting about 40 to 50 percent of all the energy that we are using, and that no real significant effort has been made to conserve.

Now, when you start talking about energy conservation and you apply any of your own thoughts about what conservation means compared to how conservation is used in ERDA's plan, you get into a problem of semantics.

Now, to me conservation means turning out the lights and carpooling and not running the air-conditioner or the heating system as high or low in the winter and summer as you normally would, all of those things which deal with the simple non-use of energy.

Whereas, ERDA in setting out its emphasis on conservation considers not only the cutting of the use of energy as a conservation device, but they also refer to certain efficiencies. For example, increased efficiency in the transmission of electricity can cut down the use of electricity and in one sense it is a form of conservation, just as is the requirement that Detroit make a fleet mix of automobiles that gets 28 miles per gallon, instead of 15 miles per gallon. That is certainly a much more efficient use of the supplies we have, but it is not in my opinion a matter of conservation.

So if you use my definition of conservation, very little of ERDA's budget is allocated to it. If you use ERDA's definition including all efficiencies that can be developed in the use of energy, then of course, there has been a bigger increase in the conservation part of ERDA's budget on a percentage basis than any other area.

But for all the energy options that are under consideration, it seems that we are primarily looking at different ways to create an electric society.

Would you agree or disagree with that Dr. Seaman?

[The prepared statement of Dr. Seaman follows:]



UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

STATEMENT OF DR. ROBERT C. SEAMANS JR., ADMINISTRATOR
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
HEARINGS BEFORE THE SUBCOMMITTEE ON
ENERGY RESEARCH AND WATER RESOURCES
THE SENATE COMMITTEE ON INTERIOR
AND INSULAR AFFAIRS

July 22 1976

As you know, the Federal Non-Nuclear Energy R&D Act of 1974 directed ERDA to prepare a comprehensive Plan to deal with near-term, mid-term, and long-term energy problems. The Congress, in requiring that the Plan be revised annually, 1 has recognized the need for an evolutionary approach to planning in this uncertain and continuously changing field.

On June 30, 1975, some 5 months after ERDA was established, we sent Congress a report (ERDA-48) entitled "A National Plan for Energy Research, Development and Demonstration. The first revision of this Plan was submitted in April of this year. 2 While the basic goals and strategy remain essentially intact, the latest report, ERDA 76-1, represents an evolution in approach over the initial planning; it expands the scope and depth of coverage; and it reflects the continuing study and analyses being conducted in support of the Plan (including greater emphasis on socioeconomic and environmental considerations in energy development).

At the same time, neither our subsequent analyses or the far-reaching changes in world economic and energy relations since publication of the initial report in June 1975 have changed our view of the basic problem. We believe we were on the right track in the ERI-48 report, and the course of direction and sources of solution outlined are still valid. The troublesome features of the energy problem that called for Governmental action are unchanged and, if anything, the urgency of the problem has increased.

A serious and continuing energy problem exists in this country. 3
We continue to rely upon oil and gas for over 75% of our energy. Further, the reliance on imports has increased not declined as hoped, and our foreign sources of supply are becoming more distant and less assured. In 1975, we imported approximately 4
40% of the liquid fossil fuels which are our primary source of energy. Natural gas is our second most important energy source and it is constrained by declining domestic reserves and subject to foreign export policy decisions. In short, we continue to rely most heavily upon our least abundant domestic energy resources.

A transition to new energy resource basis must be accomplished, 5
and that transition must take place at a more rapid pace than the historical shifts from fuelwood to coal and from coal to petroleum.

In the United States, it took some 60 years to make the transitions from one fuel source to the next, and we cannot afford a 60 year period to make the next transition.

Studies of our recoverable domestic energy resources show that a number of alternative sources would offer tremendous potential if the technologies were available for their exploration and economic use. Given the technological means to harness geothermal sites and to exploit oil shales, these two sources could supply more energy than our ultimately recoverable resources of oil and natural gas. Coal alone, could supply several times more energy. Uranium, with the present light water technology, could supply about the same energy as the total recoverable resources of oil and gas, but with breeder reactors the same uranium resources would provide about 60 times more energy. The ultimate potential of solar and fusion energy is virtually unlimited.

It has been estimated that conservation could save over one-sixth of the energy that would otherwise be consumed in the next 25 years. This saving would be about equal to seven years demand at the current rate of use and equivalent to one-half of our estimated recoverable resources of petroleum. At the same time, it is clear that simply curtailing demand growth will not solve the problem or greatly postpone the eventual need to shift the Nation's energy consumption away from our diminishing supplies, of gas and oil.

Our domestic production of crude oil has been declining since 1970, and even the large increment of new supply from Alaska will probably arrest the decline for less than a decade. If world oil production levels are maintained at the current rate of 20 billion barrels each year, even the vast foreign reserves of petroleum will be seriously depleted in about one generation.

Changes in supply patterns and new directions in energy development are inevitable. The choices we make now and in the next few years will determine whether we can make an orderly and acceptable accommodation to change or face the disruptions and disappointments of curtailed or inadequate energy supplies.

We believe that the key to the eventual solution of our energy problem lies in the development and application of new technologies. Technology development is necessary for almost every aspect of the problem, including alterations in the existing energy systems. In the longer term, solutions to the energy problem require the emergence of technologies still decades from large-scale application.

Sudden and disruptive change in global energy operations have heightened uncertainty and created the need for an accelerated pace of readjustment. In these unusual circumstances, we cannot be sure that the RD&D conducted in the private sector will be sufficient to meet our needs. Uncertainties regarding profitability, environmental standards, technological risks or, simply, the sheer

size of the effort may be too much for private industry to overcome on its own. We realize that energy is a national problem. It must be attacked through national policy and a primary element must be an effective national effort on energy RD&D.

ERDA has a Congressional mandate to plan and direct that effort. This is a unique and formidable responsibility, but we recognize that it is not a mandate to plan the social and economic future of this country. Our energy policies and programs must be designed to support our broader national goals for economic development, social progress, environmental quality, national security, and for amicable relations with the rest of the world.

However, ERDA has a responsibility to study, to appreciate and try to foresee the pace and pattern the American society will set in the future. Our mission, then, is to assure that social and economic aspirations are not unduly abridged by inadequate supplies of energy or lack of choice among energy alternatives.

The important first step in developing a national plan is to map a strategy to accomplish goals in the most effective and least costly manner. Timing is an important factor in developing any new energy resource and in planning a strategic approach for energy R,D&D. It should be clear, for example, that one of the reasons we stress conservation is that it requires the least amount of time before we can begin to see a payoff. It can permit us to buy time

and provide continuing economic and environmental benefits of reduced demand. In the short-term, we also stress efforts to increase recoverable amounts of domestic oil and gas and overcome problems to allow increased use of coal and nuclear power. In the mid-term, from 1985 and beyond, we place more emphasis on processes for producing synthetic fuels from coal and extracting oil from shales. At the same time, we want to conduct our R,D&D strategies so as to provide some margin for potential failure by broad-based programs rather than banking too heavily on a single energy resource. Finally, our strategy calls for a serious effort now to reach for an eventual energy system dependent on inexhaustible or renewable domestic resources. These include solar energies in various forms and nuclear fuels either with fission breeder reactors or with fusion.

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It must be realized that all of our new technologies will have to follow a long and arduous course from concept, through exploratory research, development, pilot stage, demonstrations, initial commercial-sized operations and finally to significant market penetration. The further away from commercial introduction the less likely the private sector will support the R&D effort. Expenditures on fusion are predominantly Federal investments today while the private sector has assumed the major role in enhanced recovery of oil and gas or in efforts to improve the direct use of coal.

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The Federal role, however, is largely supplementary to the private sector especially as we move closer to commercialization of a technology. Decisions are perceived as an outgrowth of market forces with the private sector determining the ultimate mix of energy sources and technologies to serve our needs. The unique feature, therefore, of ERDA as compared with NASA, the Department of Defense, and most other Federal agencies, is that we do not use our end products. We don't have missions to go into orbit or to the moon. Our end product is the development and demonstration of technologies that are useful only when applied on a significant scale by private industry. This pattern of technology transfer is unlike the historical paths of development and use.

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The role of the private sector is, therefore, paramount in the eventual application of our energy technologies. It is the primary vehicle to achieve resolution of the Nation's energy problem. A vigorous industry with many individual decisionmakers has the inherent flexibility to act. It has access to the investment funds, and possesses the managerial capability for carrying out the commercialization of new technologies.

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The governmental participation and the expenditure of public funds are to supplement private action and accelerate the process of readjustment to disruptive changes in energy operations. The budgetary expenditures reflect that purpose, but a word of caution

is in order. The national energy priorities cannot be directly connect i to the ERDA budget in any single year. This is true because he program efforts is a function of its status in the wide spectrum from research through market application. The expenditures may not, therefore, reflect program priorities. Further, the distribution of effort and expenditures between private and public participants vary from project to project. Finally, R&D is only one mechanism for government involvement and agencies other than ERDA have additional responsibilities in energy RD&D.

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The budgetary authorizations for Federal energy R&D were set at \$2.7 billion for FY 1977, and the ERDA budget includes over \$2.4 of this total. At the same time, the total ERDA budget including national security and other operational and support programs amounts to \$5.3 billion. ERDA's energy RD&D funds, therefore, are only 46% of the total budget authorized for FY 1977.

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The \$2.4 billion authorized for direct energy R&D in ERDA's budget represents a 47% increase from total authorization in FY 1976. While this increase was distributed over all major programs, a substantial 64% increase over FY 1976. Funding has been increased 73% for nuclear fuel cycle and safeguards R&D. The objective here is to assist the private sector to close the fuel cycle for Light Water Reactors, that is, to develop the means for the reprocessing and refabrication of nuclear fuel, the storage of commercial reactor wastes, and the safeguarding of nuclear materials. Fossil

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energy was increased by one third to expand programs such as the direct use of coal and enhanced oil and gas recovery. Increases for other major energy resources were about the same as for fossil fuels.

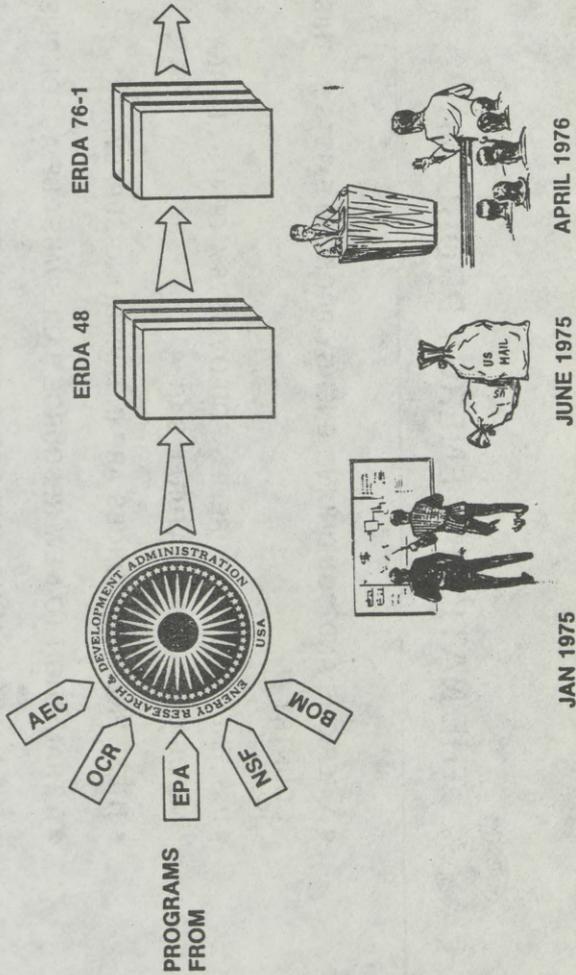
As indicated earlier budgetary levels and changes do not fully reflect the major thrusts or focuses of the Plan. At the same time, the following summary indicates a degree of correspondence. The National Plan focuses on assisting industry to accelerate 7 key technologies or programs. These include: (1) conservation technologies, (2) nuclear fuel cycle programs, (3) enhanced recovery of oil and gas, (4) increased direct use of coal, (5) synthetic fuels programs, (6) expanded use of geothermal energy, and (7) the introduction of solar heating and cooling. These are the technologies and programs at or near commercial application, and the Plan aims at promoting their penetration of the market.

The long time spans from the original conception of a new energy source to its significant market penetration means that, if we are to gain any benefits within a time frame useful to us, we must begin the necessary work now. We must begin work even for some distant goals, and we must sustain an active pace of RD&D on some technologies that will have little impact before 2000. Complex technologies are simply not susceptible to last minute pushes when we suddenly realize that they are needed.

**A NATIONAL PLAN
FOR
ENERGY RESEARCH,
DEVELOPMENT
AND
DEMONSTRATION
CREATING ENERGY CHOICES
FOR
THE FUTURE 1976**



EVOLUTION OF NATIONAL ENERGY RD&D PLANS

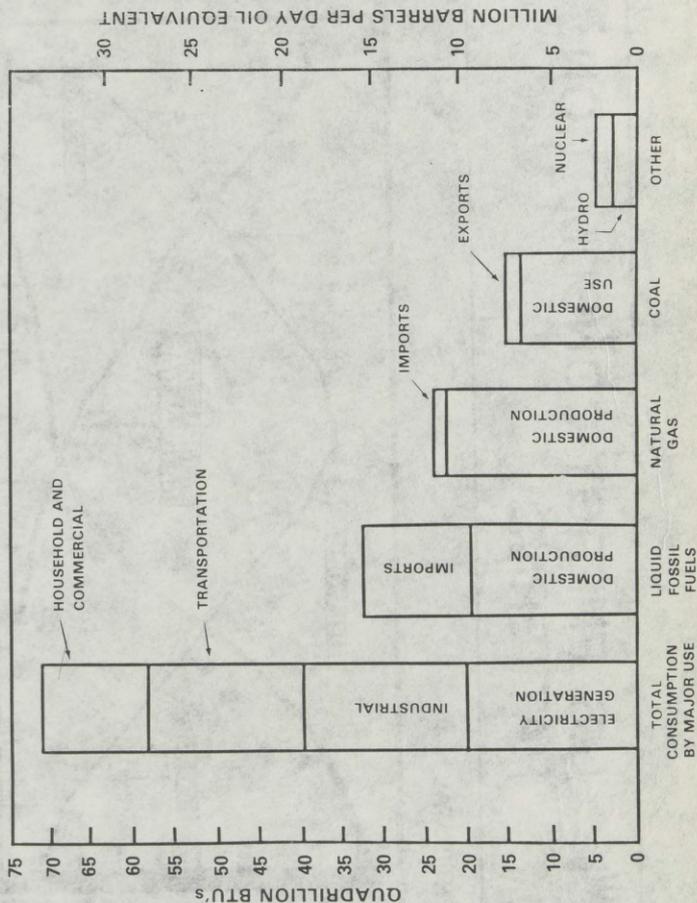




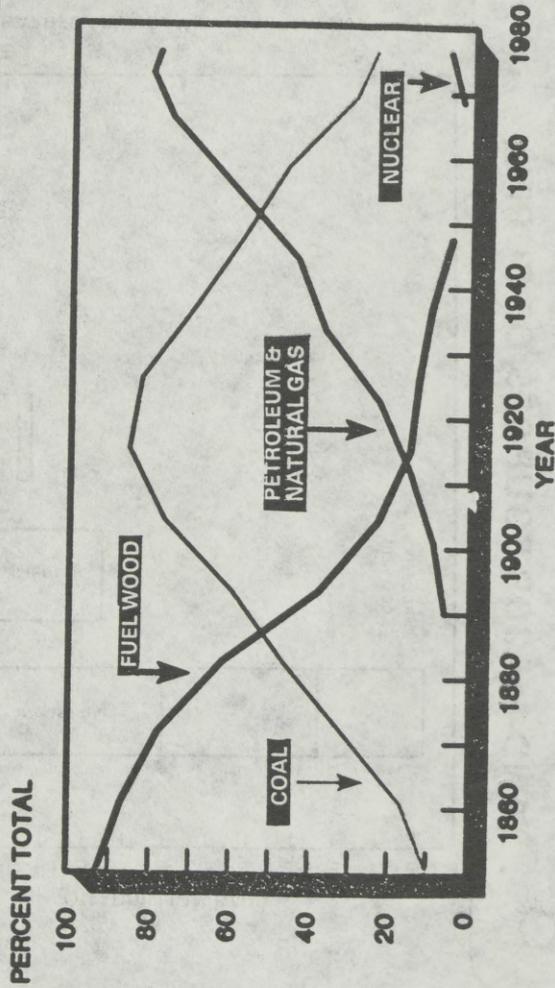
THE NATIONAL ENERGY PROBLEM

- A SERIOUS AND CONTINUING ENERGY PROBLEM EXISTS IN THIS COUNTRY
- U.S. ENERGY SYSTEM RELIES FOR OVER 75% OF ITS ENERGY NEEDS ON OIL AND NATURAL GAS
- THESE ENERGY SOURCES ARE IN DWINDLING SUPPLY
- A TRANSITION TO NEW RESOURCE BASES MUST BE ACCOMPLISHED
- THE NATION CANNOT AFFORD A 60-YEAR PERIOD TO MAKE THE NEXT TRANSITION

U.S. ENERGY CONSUMPTION IN 1975 AND MAJOR SOURCES OF SUPPLY

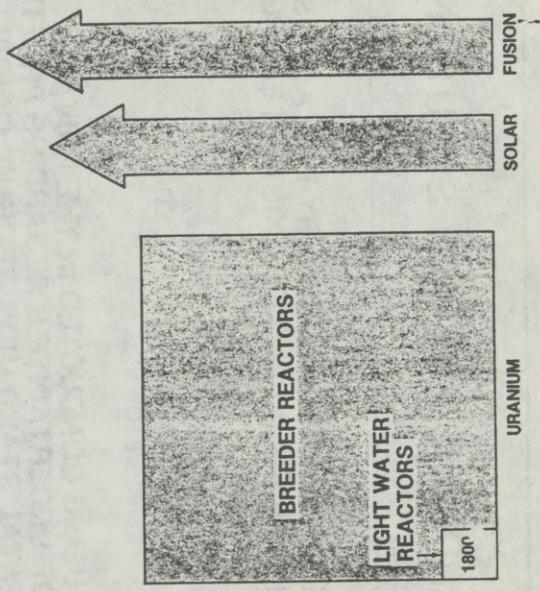
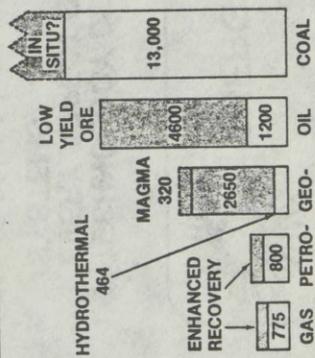
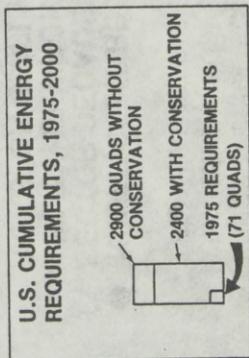


U.S. ENERGY CONSUMPTION PATTERNS





RECOVERABLE DOMESTIC ENERGY RESOURCES





ENERGY RD&D IS PRIMARY SOLUTION

- **TECHNOLOGY DEVELOPMENT IS NECESSARY FOR ALMOST EVERY ASPECT OF PROBLEM-INCLUDING EXISTING ENERGY SYSTEMS**
- LONGER TERM SOLUTIONS TO ENERGY PROBLEM REQUIRE THE EMERGENCE OF TECHNOLOGIES STILL DECADES FROM LARGE SCALE UTILIZATION
- **INSUFFICIENT RD&D BEING CONDUCTED IN THE PRIVATE SECTOR BECAUSE OF UNCERTAINTIES REGARDING PROFITABILITY, ENVIRONMENTAL STANDARDS, TECHNOLOGICAL RISKS, OR SIMPLY, THE SHEER SIZE OF THE EFFORT**
- ENERGY RD&D POLICY IS PRIMARY ELEMENT OF THE TOTAL NATIONAL ENERGY POLICY



STRATEGIC APPROACH FOR ENERGY RD&D

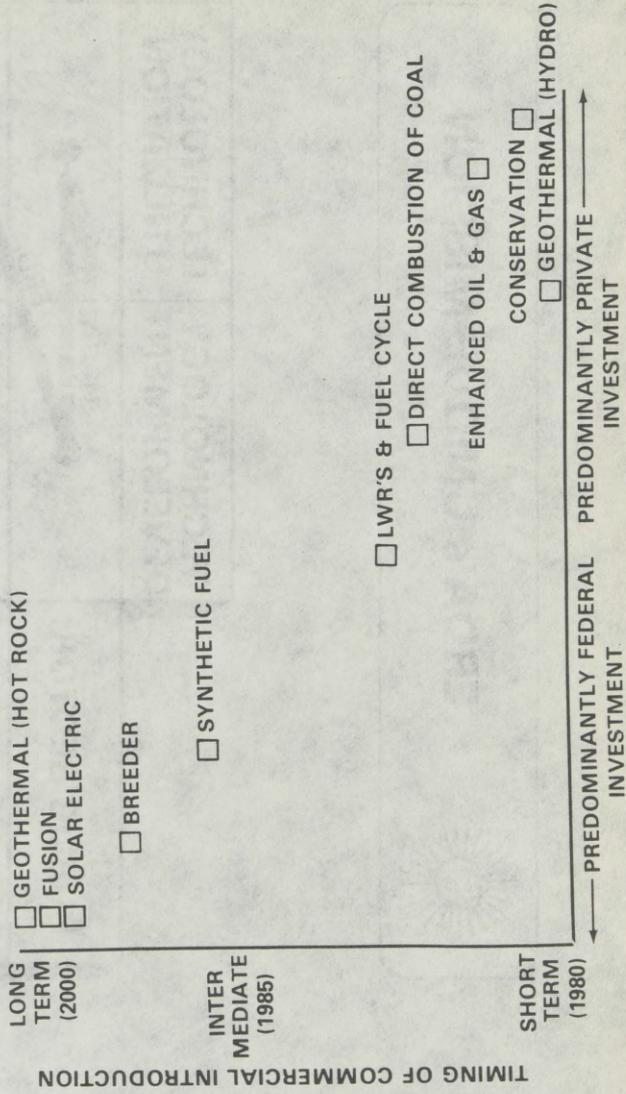
- BUY TIME THROUGH GREATER EFFICIENCY FOR DEVELOPMENT OF NEW SUPPLY TECHNOLOGIES AND PROVIDE CONTINUING ECONOMIC AND ENVIRONMENTAL BENEFITS OF REDUCED DEMAND
- INCREASE RECOVERABLE AMOUNTS OF DOMESTIC OIL AND GAS
- OVERCOME PROBLEMS TO PERMIT INCREASED USE OF COAL AND LWR'S
- EXTEND USE OF EXISTING ENERGY SYSTEMS BY DEVELOPMENT OF SYNTHETIC REPLACEMENTS FOR NATURAL RESOURCES
- PROVIDE MARGIN FOR FAILURE BY BROAD-BASED RATHER THAN SINGLE ENERGY RESOURCE APPROACH
- REACH FOR EVENTUAL ENERGY SYSTEM DEPENDENCE ON INEXHAUSTIBLE AND RENEWABLE DOMESTIC RESOURCES



THE STRATEGY OF TECHNOLOGY INTRODUCTION

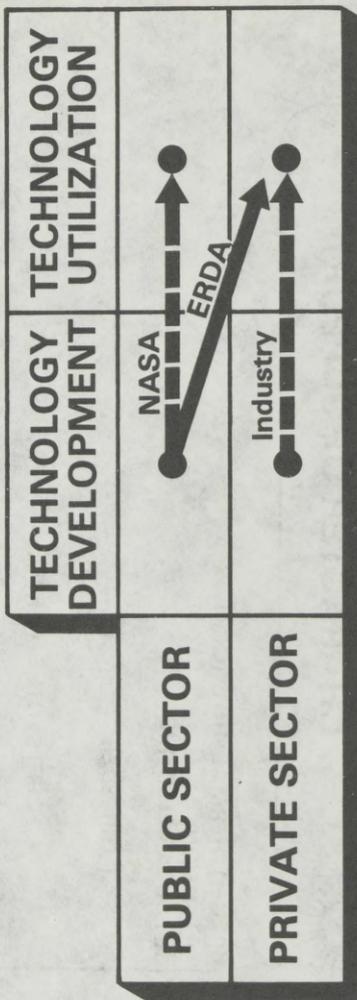
Time of Impact	Strategic Element	Technology	Impact in Year 2000 (Quads)
Near-term (now to 1985 and beyond)	Increase efficiency of energy use and convert waste to energy	Conservation in Buildings and Consumer Products	7.1
		Industrial Energy Efficiency	8.0
		Transportation Efficiency	9.0
		Waste Materials to Energy	4.9
	Preserve and expand oil, gas, coal, and nuclear	Coal-Direct Utilization in Utility/Industry	24.5
		Nuclear-Converter Reactors Oil & Gas Enhanced Recovery	28.0 13.6
Mid-Term (1985-2000 and beyond)	Accelerate development of synthetic fuels from coal and shale	Gaseous and liquid fuels from Coal Oil Shale	14.0 7.3
		Geothermal Solar Heating & Cooling Waste Heat Utilization	3.1-5.6 5.9 4.9
Long-Term (past 2000)	Develop the technologies necessary to use the essentially inexhaustible fuel resources	Breeder Reactors Fusion Solar Electric	3.1 — 2.1-4.2
		Develop the technology necessary to change the existing distribution systems to accommodate the distribution of new energy sources.	Electric Conversion Efficiency Electric Power Transmission & Distribution Electric Transport Energy Storage Hydrogen in Energy Supplies Fuels from Biomass

COMMERCIAL INTRODUCTION AND CHARACTER OF SUPPORT





ERDA's UNIQUE MISSION





PARAMOUNT ROLE OF THE PRIVATE SECTOR

THE PRIMARY VEHICLE TO ACHIEVE RESOLUTION OF THE NATION'S ENERGY PROBLEM IS THE PRIVATE SECTOR — THE NATION'S INDUSTRY AND ITS PEOPLE. IT IS THE PRIVATE SECTOR THAT HAS:

- THE INHERENT FLEXIBILITY TO ACT
- THE PREPONDERANT SHARE OF NEW INVESTMENT FUNDS
- THE MANAGERIAL CAPABILITY FOR CARRYING OUT MOST OF THE RD&D AND TECHNOLOGY COMMERCIALIZATION

THE BUDGET PRIORITIES



NATIONAL ENERGY PRIORITIES CANNOT BE DIRECTLY CONNECTED TO ERDA BUDGET IN ANY ONE YEAR BECAUSE:

PROGRAM EFFORT IS FUNCTION OF PROGRAM STATUS IN SPECTRUM FROM RESEARCH THROUGH MARKET PENETRATION AS WELL AS PROGRAM PRIORITY

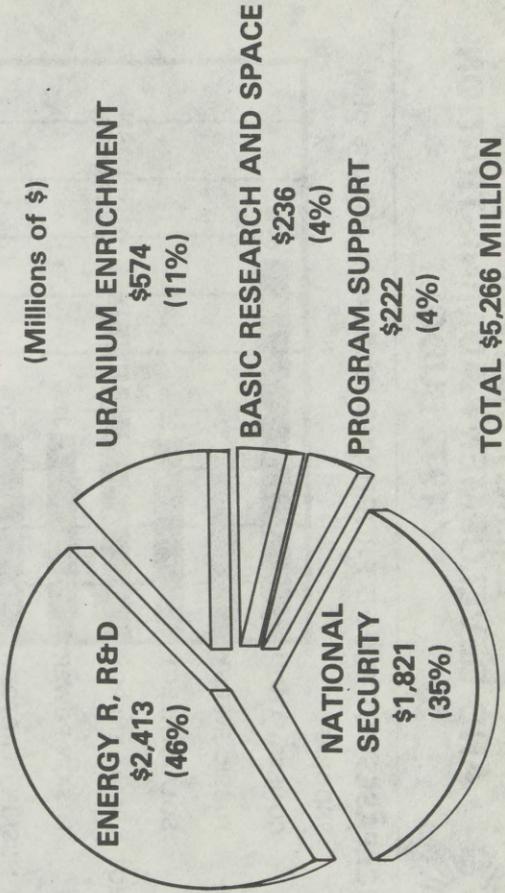
VARYING DISTRIBUTION OF EFFORT BETWEEN PRIVATE AND FEDERAL

R&D IS ONLY ONE MECHANISM FOR GOVERNMENT INVOLVEMENT

OTHER GOVERNMENT AGENCIES HAVE RESPONSIBILITIES IN ENERGY R&D


**ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION**

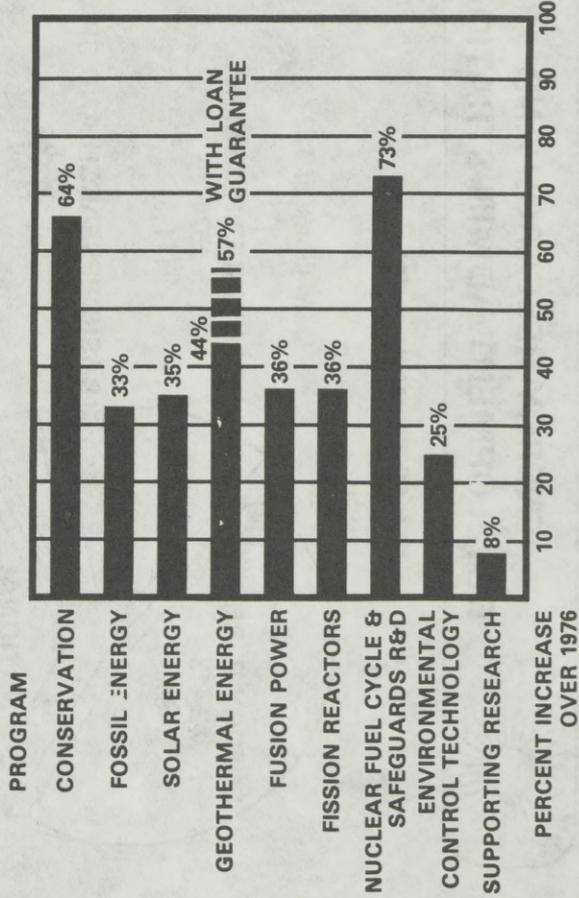
FY 1977 BUDGET





ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FY 1977 BUDGET

INCREASES FOR R,D&D PROGRAMS (Outlays in Millions of \$)





MARKET PENETRATION OF KEY TECHNOLOGIES

NATIONAL PLAN FOCUSES ON ASSISTING INDUSTRY TO ACCELERATE 7 KEY TECHNOLOGIES

- CONSERVATION (ENERGY EFFICIENCY) TECHNOLOGIES INCLUDING 5-YEAR FORWARD FOCUS
- VALIDATE COMPLETE LIGHT WATER REACTOR FUEL CYCLE IN THE PRIVATE SECTOR
- EXPAND APPLICATION OF ENHANCED OIL AND GAS RECOVERY TECHNIQUES
- OVERCOME PROBLEMS ASSOCIATED WITH INCREASED DIRECT UTILIZATION OF COAL
- DEVELOP BASIS FOR SYNTHETIC LIQUID AND GASEOUS FUEL INDUSTRY
- EXPAND EXPLOITATION OF GEOTHERMAL RESOURCES
- STIMULATE INTRODUCTION OF SOLAR HEATING AND COOLING

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ADMINISTRATOR,
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Dr. SEAMANS. No, I don't think that that is entirely true. I think we have a very great emphasis on synthetic fuels, for example. We believe that we have in this country a very, very complex internal structure for distributing oil and gas and using oil and gas for a wide variety of purposes. And that to the maximum extent possible, we should develop coal and shale and biomass conversions that permit that structure to be utilized.

And one of the important thrusts in our study is that of synthetic fuel. And if you look at our plan, very long term at fusion, at solar, at the breeder, they do generate electricity. But, in turn, that electricity may be used to develop gas, for example, and hydrogen which could be the actual fuel that is utilized rather than the transmission of the electricity.

I think it is true that there will be a trend toward greater use of electricity, but we don't look at it as a preordained trend toward 100 percent electrical use.

Senator BUMPERS. I am probably getting a little ahead of myself, Dr. Seamans.

Let me go back just a moment because what we are talking about here is addressing a very common perception across the country that this Nation does not have an energy policy, and I understand why the American people feel that way, but what I want to ask is in your opinion, do we have an energy policy? Let me ask you what ERDA perceives to be the long-range policy of this country so far as energy is concerned? Now, right now we talk about energy dependence, yet we are increasingly dependent upon foreign oil.

Now, the simple point is that we depend on petroleum and gas, and until the private sector—on which ERDA is relying heavily to solve the problem—sees the economic feasibility of developing alternative sources and until they see that they can make sizeable investments in alternative sources of energy at a price that will at the completion of the project be competitive with foreign oil, they are not going to do it.

Now that leaves the U.S. Government in the position of either saying we were only kidding about becoming independent, or that the Federal Government is going to subsidize alternative energy sources to the extent necessary to make us competitive with foreign oil. I would like your comments on whether we have an energy policy, and whether we are aggressively pursuing it.

Dr. SEAMANS. Well, you covered quite a bit of ground. I would say we probably don't have an overall national policy that everybody agrees to. And before you can call it a national policy, it must have very wide acceptance.

We, in ERDA, have done, we believe, a sound planning job. In my statement for the record, I indicated, I think, the limitations of the plan as well as the extent of the plan. But it does make several of the points that you have made. Namely, that we are relying for 75 percent of our energy on oil and gas which is a wasting asset, not only domestically but on a worldwide basis if you take the long view; that we

have got to transfer to other energy sources and we have to conserve—and both from a supply as well as from a demand standpoint.

This means that new technology has got to be utilized. That is not the only factor involved, but technology is at the heart of a great deal of what this country can do in the future. And that is where ERDA as an institution comes into play.

Part of the work, technical work, will be done by other agencies of Government; part of it will be done in the private sector. And we believe that we have the responsibility to see that there is a total national technological effort, a research development and demonstration effort.

We believe that a plan that we have come up with does put a reasonable amount of effort in all of the important areas. We can have a debate as to whether we are putting exactly the right amount—it is a hard thing to measure. It takes judgment. It has to be weighed. The amount we put in each year has to be weighed against what others are doing outside of ERDA, both public and private, as well as where we stand in a particular year in a given development.

However, we do have a national plan for research and development and demonstration. Now, beyond that you get into such issues as are we preparing right now for the possibility of an oil embargo next year?

I would say that the research, development and demonstration program cannot really help very much in that regard. You have to get into quite different issues having to do with building up our storage capacity, for example.

And the President did come in with a quite extensive program dealing with contemporary problems and there has been partial agreement of this program by the Congress that accepted some, but not all of the recommendations, and I think it is still being debated, if you will, in the public arena, exactly what needs to be done contemporarily.

Senator BUMPERS. Dr. Seamans, let me make one or two other observations for you to comment on and then in fairness to the other Senators present, I want to give everybody an opportunity to be heard this morning because I think this is a matter of considerable concern.

When we go back home we have to explain to our constituents either that we do have a national energy policy or why we don't. And I think it is critical to our future. I hope you know that I have the utmost confidence in you. I have always taken ERDA's side in these FEA turf fights because I think that energy efforts ought to be more and more concentrated into ERDA.

I have been concerned by what is an increasing dependence on nuclear power in our country. I think it is a very legitimate concern that is expressed not only by me as a layman, but some very fine scientists. An obvious alternative is energy conservation. In the area of energy conservation, we held hearings here, and I must confess that I have a provincial outlook because it dealt with two bills that Senator Church and I combined on.

His part of it dealt with what is called an energy institute program by which institutions of higher learning, at least one in each State, would be given grants from a \$10 million appropriation to develop very small energy conservation techniques that were peculiar and unique to a particular State.

For example, in my State, two of the biggest energy users are rice drying and heating of broiler houses. We are the biggest broiler producer in the United States, and we use a tremendous amount of energy to heat and cool those houses.

Thus, the University of Arkansas could have engaged in some sort of solar research that might make a significant contribution in those two areas.

The second part of the program was one that had been originated in the House, and which I introduced over here. This was the energy extension service, by which the information produced by, say, a university would be disseminated to the people who might find a good application for it. Just like the agricultural cooperative extension service takes the latest technology in agriculture to the farmers of the State.

And rightly or wrongly, I was advised that ERDA didn't think very much of the plan.

Now, to me it represented about the only step that had been taken in the field of conservation. We did some calculations on this and they are certainly subject to error, but we felt that within a 24-month period using approximately \$25 million to implement these two programs and this could within 24 months save the equivalent of the Alaskan pipeline or somewhere between 1½ and 2 million barrels of oil a day. As you know, \$25 million around here is just nothing. If you say it real fast it sounds like a quarter.

Now, I don't know whether ERDA was responsible or not, but when this bill got through here, and the House, the energy institutes were torpedoed completely and the energy extension service was cut from \$15 million to \$7½ million in the appropriation conference.

Now, the whole thrust of this was that the American people, I think, are just dying to be called on to conserve energy. There has been very little in the way of calls for sacrifice or any kind of an appeal to the Nation to solve this problem from the White House and very little from the Congress. And I thought this had great merit because anything, if it would just save 250,000 barrels a day, \$25 million a year would be a pittance to solve such a problem.

And I was dismayed that that did not receive full recognition. I am dismayed that other similar programs have not received greater recognition. And, finally, I have been a strong proponent of developing as many small technologies as possible. We throw a lot of thermal pollution into the atmosphere every day in this country that could be harnessed and used as an energy source.

I have been a great proponent of biomass conversion, as you know. I got this committee to raise the amount of research money for biomass conversion from \$3 to \$8 million. I think biomass, wind, thermal, geothermal, solar, all of those things have great potential and some things like the use of urban waste, biomass conversion, wind energy—while they look insignificant on their face, it just occurs to me that a massive effort toward the development of a lot of small projects, cumulatively and collectively, could make a significant contribution to the energy supply of the Nation.

Now, I would like you to address those two things. One, that phase of conservation; and, two, how you feel about the accelerated use of the smaller known technologies, and the ability to make a dent in our problems by the use of them.

Dr. SEAMANS. Well, it is our feeling that this is borne out by the studies that are in our planning document. There isn't any question that conservation is extremely important. There is no question that we have been profligate in this country in the use of energy and materials, and from that standpoint, we should change our lifestyle, if you will.

Our own specific studies show that by using technologies, we can use our energy more efficiently and that we could cut down by a factor roughly 25 percent the use of energy over the next 25 years. We feel it is extremely important to use these technologies.

We recognize that in the conservation field we are tending to deal with many, many different facets of our economy quite different from, for example, the generation of power with coal or with nuclear. Rather than one or two major projects that might make a very great difference as in the case of the fossil fuel or the nuclear, in the field of conservation there needs to be a very large number of relatively small projects.

This we have attempted to initiate in our conservation program and I think we have a wide variety of very interesting projects at the level of \$1 million or \$2 million. Some are larger than that.

We have, for example, a joint program that we had to struggle to get going, but I believe we now have it well underway. Senator Glenn has been a big help in getting it going. Involving the use of the fuel cell. And here we are working with utilities, we are working with industry, we are working with local governments to move that particular program along.

So I don't fault at all what you are saying that (a) conservation is important, and (b) conservation must involve working in a wide variety of areas on relatively small projects.

Now, when it comes to the matter of our lifestyle of taking more pains at home to not leave the lights on, the air-conditioning on, and to drive more carefully, to use car pooling and matters of this sort, I would agree with you that this is a desirable thrust for the country to have.

However, it does not happen to be in ERDA's responsibility. I am not saying that we are going to beg off on that point, but just to say that that has not been—we have not been involved in studies along that line.

Senator BUMPERS. Dr. Seamans, I think probably the best thing at this point—would be to proceed with the short presentation you had to make here.

Would that be agreeable?

Dr. SEAMANS. I would be happy to do that, if you like.

Senator BUMPERS. I think Senator Glenn, Senator Hatfield and I would all enjoy seeing that. So let's get into that first.

Dr. SEAMANS. All right. If I could have the first slide. And that slide shows the dates for ERDA, and just a little bit of history. It shows that we were started in January of 1975; then in June of 1975 we submitted our first planning document; and this year in April we submitted an updated version of our planning document.

This chart also shows that we were formed out of the Atomic Energy Commission, the Office of Coal Research, et cetera. Those bottom figures don't show very clearly, but what it represents is this—that in our planning we carry out a large number of mathematical studies

where we try to model the economy and we try to model the energy source and distribution of the country.

Also in our planning we have attempted to communicate with large and diverse groups of people, local government, State government, professional societies, various public interest groups. In the beginning we had to use primarily a written correspondence, letters and reports. More recently we have had more time. We have had public hearings on our planning in the States of Washington, Colorado, Illinois, Georgia. We have more planned for the future.

The next slide just emphasizes what has already been said here in this room; that we have a very serious problem; that it is a deepening problem and the problem really boils down to the fact that 75 percent of the energy that we use comes from oil and gas; that our own supplies are dwindling as are the world supplies; that our own production is now down 15 percent in both oil and gas from its peak volume, and that we must make a transition to other forms of energy. And we must do it quickly.

To put that in perspective, I would like to use this chart that shows that 1850 we were using primarily wood, and in the period 1900-1920 we were using primarily coal, and now 60 years later we are using primarily oil and gas. And we submit that we do not have 60 years to make the transition to some other form of energy.

Just a snapshot of where we stand today. we get 46 percent of our energy from oil—we are importing roughly 40 percent of the oil that we use. Natural gas supplies a somewhat lesser amount; and coal, less than 20 percent. Hydro and nuclear, 3 to 4 percent apiece. Our energy is going into—over a third of our energy is going into household and commercial, 25 percent in transportation, and the remainder is going into industrial use.

Senator BUMPERS. Give us that last figure again, Dr. Seamans. What were those percentages?

Dr. SEAMANS. Thirty-eight percent, household and commercial; 25 percent, transportation; and 37 percent, industrial.

Now the next chart is the one we could spend all kinds of time on and I won't take the time here because I know your time is very limited.

It shows over in the left hand corner two small blocks, one for gas and one for petroleum. The size of the blocks indicates the available remaining resources that we have in this country. The little shaded area on the top of each of those blocks shows the additional amount of energy that we believe we can get from enhanced recovery which means new methods for tertiary recovery after we have done all the normal things that have been done in the past to get the oil and gas out of the ground.

But even if we are successful with our enhanced recovery, and we believe that is important, we can note by looking at the other blocks that we have roughly 70 percent more energy in geothermal than we have in our remaining resources of gas and oil.

We have even more oil shale available. We have in coal roughly seven times as much energy as we have in our oil and gas. As far as our nuclear capability, if we stick with the light water reactor system. we have roughly the same amount of energy available as we do with our oil and gas.

But if we go to the breeder reactor, we can increase the amount of energy availability by a factor of about 60 times. We note that our solar is essentially infinite. We note that fusion is essentially infinite.

And then from a small block up in the top left hand corner, we can see what our use has been and if we project our use taking into account our population growth and the fact that we believe that there are some needs in certain parts of our society that have not satisfied as yet, and we must allow for growth, that we will end up with roughly 2,900 quads being required for the next 25 years.

This can be reduced to 2,400 quads by conservation. And this is the 25 percent figure, roughly, that I referred to earlier.

Now, to make use of each one of these energy sources, we have got to do some technological work. In the case of the geothermal, if it is live steam, that is fine. We don't have very much live steam.

We have one powerplant system that is north of San Francisco, but to even get into the geothermal hot water systems requires some additional work; to get into hot rock requires a great deal of work. And all of that is required to get at that energy that we show in that block.

As far as shale goes, we know that there are just some basic mining problems getting all the rock out of the mountain that would go to above ground retorting. We know there are problems of water. There are problems of what to do with the wastes. We believe that we should be making more effort toward in situ type operations, but we still don't really know all there is to know about that field.

As far as the coal, we have got to learn how to burn it more efficiently, to burn it in such a way that the emissions are reduced to make the coal satisfactory from an environmental standpoint. We know we have got to do a great deal on mining, both surface mining and below ground mining to get at the environmental problems to make the mining operation safer for miners in the deep mines.

We know we have got to learn more about the processing of coal to get synthetic fuels, as in the case with the shale.

In the case of the light water reactors—the effort there from a technological standpoint has got to be not so much on the reactors as on the fuel cycle. We have still got to resolve reprocessing, recycling and have got to demonstrate that we have it.

Now, when it comes to the breeder, the solar and the fusion—I won't take time to go through them in any detail except to say that each of those areas requires intensive effort from a technological standpoint.

The next chart says that technological development is necessary for almost every aspect of our energy development. It points out that the longer-term solutions are of such a nature that we cannot expect, say, fusion to be helpful from an energy standpoint for 35 to 40 years. There is a great deal more scientific technical work, as well as demonstration work to show that fusion is economically viable if we can pass the scientific hurdles.

It says that insufficient research and development is being conducted in the private sector because of the long-term high-risk efforts required. You can't expect the industries—to invest when they cannot realize a return for 30 or 40 years.

There are also issues of environmental standards and in some cases there is just a sheer weight or sheer magnitude of the job that tends to inhibit private investment.

The next chart tells us that we should buy time through greater efficiency. From our standpoint, that is what we mean by conservation. It says that we must do everything we can to recover all of the oil and gas that is available; that we must make use of our coal and our uranium and our light water reactors; that we must get on with synthetic fuels; that we must have a broad based program because we can't guarantee that every one of our technological approaches is going to pay off.

And with that, we will go onto the next chart which is an attempt to show that as we go to the longer term, the investment is predominantly public or federally financed; that as you proceed over to the right with the shorter term payoff, you can and will get more private investment.

And, of course, somewhere in the middle, for example in the light water fuel cycle, we have a mix of both private and public funding.

The next chart is one I like to use to explain the difference between ERDA and, say, NASA. NASA has a good objective doing technological work with the same order of complexity as what we are doing. However, they utilize their own technology for exploits such as the one at Mars that we are now viewing, the Apollo program and so on.

Whereas we, in ERDA, are really a catalytic agent, if you will, for laying a base so that the private sector can come along and make use of the research and development.

We believe that this is a policy that the country expects. We believe that it is proper for the private sector to operate our energy systems, as they have the ability to make the large investments. Capital investments run in the order of \$250 billion a year privately. And they have the managerial capability to come in with the new energy systems when the technology is developed.

The next chart makes a number of points. One, that when you look at our budget you are not looking at all the Federal Government is doing in research and development, you are looking at about 85 percent of it.

Second, that when you look at our budget for 1 year, you can't determine the priority in a sense because some of the programs that are very important are just getting started. And, hence, if you compare budgets right now, they don't demonstrate that importance—they are not the same level as some of the more mature programs that have been going for a considerable period of time.

But there is some distribution of effort between private and public, and then we go on and take a look at the pie chart that shows how we are distributing our money in ERDA. And this shows that less than half of our funding is going into energy research and development; that another 11 percent is for energy, but for uranium enrichment. We are, in effect, a manufacturing organization selling services.

That 35 percent is for national security; around 4 percent for basic research and our space effort—and I might say here that the power supply for the Mars landing was made by ERDA or its predecessor, the Atomic Energy Commission, in making use of plutonium and it is working very well.

And the remaining 4 percent is for program support: payment of salaries and so on.

The last chart I have just shows the growth from 1976 to 1977 in the President's request. The largest percentage increase go to address safeguard problems and the nuclear fuel cycle. The next, conservation. The

next, geothermal. And the remainder all showing an increase of around 30 or 35 percent.

And with that, I guess in the interest of time I have covered all the points I care to point to.

Senator BUMPERS. Thank you very much.

Senator Hatfield, do you want to question Dr. Seamans?

Senator HATFIELD. Mr. Chairman. Dr. Seamans, we have some information here in the report relating to the distribution of research money in the geothermal area between in-house labs or governmental labs and industry or universities and other labs.

Could you tell us in the overall research and R. & D. of the budget, 46 percent of that budget, what percentage of that is in-house research?

Dr. SEAMANS. Well, first, just one word of definition. We don't really do very much actual in-house research in government labs. We have five government labs that we inherited from the Bureau of Mines. They have been doing some work in below ground in situ type operations, but we do have our national laboratories, we do have our government-owned contractor operated facilities. And when we talk about our in-house, I think it would be only fair to include those as well.

And I believe that our research and development breaks roughly down to about 80 percent in-house by that definition, and about, I believe, 20 percent to external.

Senator HATFIELD. This includes the old AEC labs?

Dr. SEAMANS. That is correct. I am talking about overall effort.

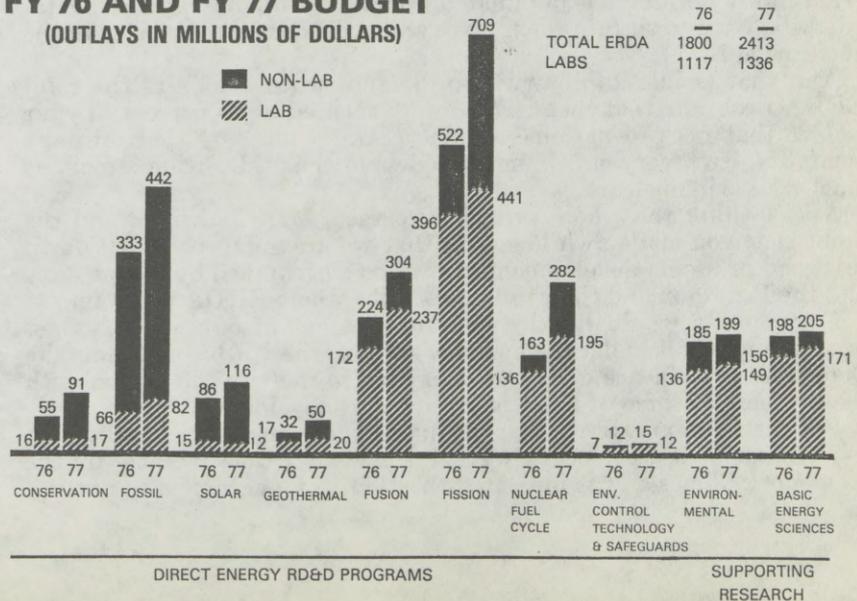
Senator HATFIELD. Well, I am looking at this budget; 46 percent of it is going into energy R. & D. And I would just be interested in knowing how that 46 percent or \$2.4 billion, how much of that is dominated by government labs, and how much of it is distributed out to private and in industry and in university labs and other such laboratories?

Dr. SEAMANS. Our—

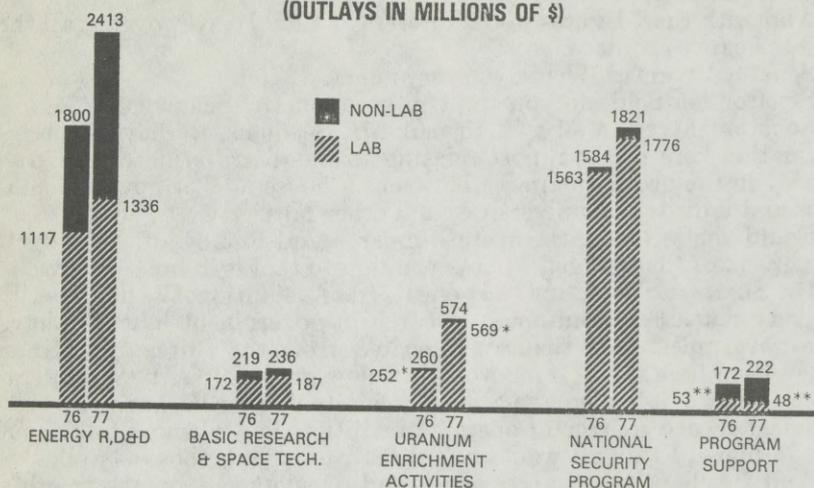
Senator HATFIELD. Could you get that for the record?

Dr. SEAMANS. I will supply that for the record.

FY 76 AND FY 77 BUDGET
(OUTLAYS IN MILLIONS OF DOLLARS)



ERDA BUDGET (OUTLAYS IN MILLIONS OF \$)



* NET AMOUNT AFTER APPLICATION OF REVENUES FOR: (a) TOTAL ENRICHING BASED ON COST RECOVER CHARGES (-591 IN 76; -539 IN 77); (b) ADDITIONAL TOLL ENRICHING CHARGE UNDER LEGISLATIVE PROPSAL (-22 IN 76; -41 IN 77).

** NET AMOUNT AFTER APPLICATION OF MISCELLANEOUS REVENUES (RADIOISOTOPES -79 IN 76; -76 IN 77).

Senator HATFIELD. Let me just illustrate it because I think probably this is one of the problems that the chairman has already identified today, and that is this overemphasis that I am showing in expressing my concern on nuclear to almost the detriment of other sources of research.

In the geothermal area alone in fiscal 1976, of the total amount \$31 million, we had 17—over \$17 million in national labs. And if you want to go into the question of the emphasis on nuclear, I think you will find—because we have the old AEC labs—and the whole ERDA program in my opinion has dominated because of in-house governmental labs who have to sustain themselves and their concern is mostly in the nuclear field.

And that is just an observation, because when I look at the total ERDA program, that then is also supplemented by 35 percent of your budget that goes to national security. And I am sure that military mentality isn't very much interested in ocean, tide, wind, solar, as much as it is in nuclear.

And I think the whole problem we face, Mr. Chairman, and the point that you made awhile ago, is that we are going pell-mell down this road of fission development motivated a great deal by the military and the Pentagon and their influence in the whole ERDA program.

I personally would like to separate that out of our whole budget process and put it under the military budget where it belongs and take that kind of influence out of your agency so that we can get on with the business of some of these other areas of development.

For instance, may I ask you the question are we doing anything in the area of ocean, the ocean waves? I saw an article recently by the New York Times and it indicated the British Government is putting

up almost \$2 million for a 2-year research project in four schemes of harnessing the waves. What are we doing in that area?

Dr. SEAMANS. As far as the ocean waves are concerned, we have essentially no efforts. We have a considerable effort on ocean thermal gradients. There is an organization known as the International Energy Agency of which the British and we are a part. And we have reviewed the use of energy from the oceans and at the last meeting we had, Dr. Marshall, who is in charge of the British program indicated that they were going to emphasize the waves. We pointed out we were going to emphasize the thermal gradients and we would be comparing data, one with the other. And maybe we should do some additional work in that area.

But right now, the ocean thermal gradient appears to be the more attractive investment.

Senator HATFIELD. Dr. Seamans, it seems to me that about 2 years ago when you were up here we were talking then in the development of this ERDA concept, you recall. We had a colloquy in which I indicated that I had a great deal of confidence in the garage inventor and the basement lab. And that many of these projects oftentimes became the sources of great inventions.

But they were needed. The funding there might be only \$1,000 or \$2,000 to put them into some kind of a demonstration phase. If you recall, I indicated that ERDA would look at some kind of a State agency or an aegis that would be created within a State for distribution to the small inventor because the processing of such requests would be difficult both from his standpoint and from your agency's standpoint if they were all flowing over to you.

The State of Oregon—I communicated that concept to the Governor and the State of Oregon did set up such an agency for recognized scientists that can make such evaluations from the request of the small inventors in those States.

Senator BUMPERS. If the Senator will yield, you will recall that we, in this committee in marking up the authorization, voted \$10 million in there and it got torpedoed in the appropriations conference for that specific purpose.

Senator HATFIELD. Certainly. I am wondering at this point, Dr. Seamans, if the agency has made an inventory of States, the 50 States, as to what States do have such a system or scheme that moneys could be funneled if they were appropriated?

Dr. SEAMANS. Well, first, I agree with you. And a lot of good ideas do come from small groups or individuals. We recognize this, for example, an inventor with a company consisting of himself and a secretary and maybe a couple of others had an idea for a new kind of a light bulb and we are supporting that effort to see whether that concept can be brought through and then the design could then be produced in quantity.

ERDA, in cooperation with NBS has an on-going program called the ERDA/NBS energy-related invention program. The purpose of this program is to fulfill the legislative requirements of section 14 of the Nonnuclear Energy Act of 1974—Public Law 93-577—by more effectively tapping the full spectrum of talents available in our country, of potential aid to ERDA in the fulfillment of its mission.

The NBS function is to act as a screen for ERDA and examine all ideas submitted to determine their technical feasibility and their initial commercial practicability. The purpose of their evaluation is to recommend or endorse an invention for consideration for further support by ERDA.

When the idea is endorsed to ERDA it comes to the Chief, energy-related inventions program, in the Office of Industry Relations. This office becomes the focal point for all further ERDA support. Based on reviews with the appropriate ERDA program officials, the idea is either supported internally within ERDA or assistance is given to obtain private sector support.

The entire energy-related invention program has been conducted on the national level by ERDA headquarters and NBS. Generally, MOU's with the various States do not specifically address energy-related inventions.

Senator HATFIELD. How many States do you have an inventory on how many States have such an agency, or some—

Dr. SEAMANS. I think almost every State has some form of energy group, energy advisor to the Governor. But it varies considerably from State to State. The extensiveness of the operation.

Senator HATFIELD. Once the Bureau of Standards makes some sort of affirmative or positive assessment of an invention, what happens then?

Do you have a lot of money or a number of projects that you could give to the committee, if not today, for the record?

Dr. SEAMANS. We will supply for the record the status of that review and what we are doing about it.

Senator HATFIELD. I would like to know how many the Bureau of Standards has submitted to it, how many they have processed, how many they have transmitted to you, and how many you have funded.

Dr. SEAMANS. To date, six inventions have been submitted to ERDA. One has been rejected for direct ERDA support, but an unsolicited proposal based on the original idea is under consideration by ERDA. One has received financial support to aid in the marketing of the idea and an interagency group is undertaking a joint effort to obtain maximum distribution of literature related to the class of products into which this invention falls. Two are in process of being considered for direct program support for further development. The remaining two, received by ERDA in the last week, are now in the hands of program personnel for review.

As of August 26, 1976, NBS has received for evaluation approximately 3,000 inventions which are in various stages of processing. Action has been initiated on 2,700 and completed on 2,000. Based on this experience it is estimated that 2 percent, or 60, of the 3,000 will be worth recommending to ERDA. Approximately 15 inventions per day are being received for evaluation.

Senator HATFIELD. Is there a problem that you see as far as moving the technology from research to a demonstration project?

Dr. SEAMANS. Yes. I think—I believe that the movement from development over into commercial use is the most difficult job that ERDA faces or the country faces, for that matter.

The mechanism that we have been using is to go through a demonstration phase which involves joint funding, private and public. We

have a number of programs of that sort. But the phase that follows is the even more difficult one. I think, because oftentimes these programs are so large and there is still uncertainty with regard to the economics or the environment or what the regulations are going to be.

And this is where we get into the possibility of loan guarantees, price guarantees. And this is still a matter that is unresolved. We still do not have full authority to go ahead.

For example, we sent up legislation on synthetic fuels with loan guarantees.

Senator HATFIELD. Is that problem of not having this resolved a matter of the ERDA agency, or is it a matter of primarily OMB?

Dr. SEAMANS. No. I would say it is a matter for the Congress to decide. The matter of the synthetic fuels, the one that the Senate authorized through an amendment to our authorization bill last year, but then the House did not follow suit. So it fell out in conference.

The House has held many, many hearings since then this spring. And we are very hopeful that a bill will be passed that will be then acceptable to the Senate and we can move out and move into near commercial-type demonstrations.

Senator HATFIELD. One last question. Dr. Seamans, as you know, I sat on your budget and your appropriations committee. And I am constantly—

Senator BUMPERS. Do you mean that literally you sit on it?

Senator HATFIELD. We implemented. I sit on the subcommittee.

The problem we have there oftentimes is we listen to your testimony in the appropriations committee hearing and make a judgment on the amount of money that can be effectively expended. Then we go to the floor and there are a lot of exotic and attractive areas of energy potential and we oftentimes find ourselves with our colleagues on the floor wanting to increase, and usually it is an arbitrary figure.

We have put in \$35 million. They think \$50 million, or so, is better. So we find ourselves trying to defend the appropriations subcommittee level of funding against the popular exotic areas of energy potential which brings forth the votes to add to that budget.

Now, my question to you is they are in danger of pumping more money that can be effectively utilized in some of the popular programs which means that we are really not getting a return on the investment. You know, I have been critical of the imbalance between nuclear and non-nuclear.

And yet I think there is a level of funding at which beyond which we really aren't getting a return. Would you care to comment on that?

Dr. SEAMANS. Yes. I would be happy to.

Any particular program—let's take as an example, solar electric involves a series of steps starting with breadboarding in laboratories, roof tests, that kind of thing; must then follow into some kind of a large scale facility like the one that we are now planning in Albuquerque to better understand the various thermal transfers from use of mirrors to, say, a boiler up in a tower to the generation of steam, or some chemical process. We must have that in hand, or well along, before we can plan the next step which is to generate electricity in a still larger type plant.

At the same time that we are doing that, we must be bringing along supporting technology on drives for mirrors and ways of directing

the mirrors in a most economical fashion. What the boiler is going to consist of, that is up in the tower; the materials and so on.

Now, if you try to force draft a program like that by, say, doubling the funding in any given year, it is going to be wasted effort. We don't have the teams available. We don't have the trained manpower. We don't have the ability to properly monitor and direct the effort.

You can look at any given program and if you really force draft it, as in the kind of thing you might do in a very, very great emergency, you can be sure there will be very great inefficiencies and you only save a very limited amount of time.

Obviously, another extreme where you proceed too slowly and things drag on and on, and that is also providing wasted effort because the overhead cost will become predominant.

There is some optimum speed for any given set of projects. That is what we have attempted to lay out in the solar area.

Senator HATFIELD. This is really a circular form of question that I have used this morning because I am coming back down to my first question.

You see, I can look at it and I can see it from your point of view in the budgetary process, but the thing that always bothers me and that I almost feel the most vulnerable point of defending our budget appropriation level on the floor when those amendments are offered is that we really have not reached out to all of the possible areas of research that are available in this country, and we are looking at these budgetary request figures oftentimes locked into an in-house governmental lab.

Now, we have said that we cannot utilize wisely some of the additional requested moneys vis a vis the amendment process on the floor. In certain areas where I know specifically there are labs and there are personnel and there are projects on the drafting board ready to go, but because they have no funding they are not able to go.

And, therefore, if we had those additional funds, they could be stimulated and put into action. Now, there is a vulnerability and as a member of the appropriations committee on the floor we can defend that level of funding that you have requested from an in-house lab and from a government lab and I think that is our basic problem in this whole research area is this overemphasis on nuclear. The governmental labs that have to be sustained and the military part of the weapon system in your whole budget. Now, that is my judgment of the problem we have in this funding of research and development.

Senator GLENN. Will the Senator yield for a question?

Senator HATFIELD. Yes.

Senator GLENN. Do you have any specifics in mind where on the floor we push for a figure you felt was particular wasteful?

Senator HATFIELD. I haven't suggested that they were wasteful at any point. I am saying that, what I am talking about here is we have an example where the request was made for the solar electric application of \$84,300,000. The House authorization was \$148 million. The Senate authorization was \$133 million. And when we ended up in conference it was \$144 million.

Now, my point is that we have tried in the appropriations to keep it at a level with some reference to the request. We have had in the solar field, we have had in the geothermal field additions made on the floor

of the Senate. I have tried to defend the appropriations committee level, not on the judgment that this is not wasteful, but it is just whether or not we can properly expend it.

And I come back to my question again, as I say, our problem is basically that we are geared to a governmental research program, an in-house lab program that we really haven't reached out and utilized the universities, industries, as much as we might.

Senator BUMPERS. Senator, I might make one observation regarding the thrust of the Senator's statement. And I recall one day in this committee room there was a markup of a proposed solar energy application that ERDA is proposing in Albuquerque and I forget who was testifying that day, but the point was made—we were inquiring about additional money and the point was made that is the highest state-of-the-art; we can give you twice as much money as ERDA is asking for, but that is still the plant that you are going to build because there was no way to spend additional money in that particular field.

And, of course, we are always confronted with the very point that Senator Hatfield is making and that is we want to be sure you have enough money for this critical problem, but we don't want to take the normal government tack of throwing money in the trough. And I was very impressed with the witness' debate and reaction to that that day because he pointed out it didn't make any difference how much money we gave him, that was still going to be the demonstration plant that they were going to build.

Senator HATFIELD. We have to get around the OMB, too.

Senator BUMPERS. But the other side of that, Senator Hatfield, is that I was terribly dismayed when the appropriations committee threw the small grants program out. I was terribly dismayed when they threw out the energy institute program.

It appears the appropriations committee didn't have the proper facts, the Senator from Oregon being the exception, since he has the opportunity to sit here and hear the technological arguments, and then sit on the appropriations committee and hear the monetary arguments.

Senator HATFIELD. The Senator is exactly correct. I wouldn't disagree at all on those points he makes concerning the appropriations committee. We get down to an overall figure. Then we have to start looking at the allocations within that figure. And oftentimes we are moved to increase certain areas and decrease others.

But I think we are really facing here a very significant problem and that is I am not certain in my mind that ERDA has an inventory, a proper and a full inventory of the potential in this Nation as a whole beyond the governmental labs to utilize wisely funding for various and sundry research development projects.

I am not fully persuaded that we have been able to establish a good system of moving technology from the pure scientific research to applied research in terms of demonstration projects.

I feel, also, that we have to reach out once we do have certain technology through an extension service to get it out where it can be utilized. Those are some of the factors that bother me as to the whole program. It is one thing to pump money into research and it is another thing to get that research out into implementation and application.

Dr. SEAMANS. If I might respond to a couple of points that you make, Senator Hatfield.

First, is that I agree with you, and as a matter of policy we are attempting to follow a pattern of getting more of the work out in universities on campus. We have just recently brought into our organization Dr. Ken Picha who is the dean of engineering at the University of Massachusetts.

We have a study that is going on right now with the university people all over the country looking at the ways, not only to develop the technology, but to train the manpower and educate the manpower for the future.

I think that moving out beyond the confines of the existing laboratories is absolutely essential. I do think, however, that we have a very great capability in these labs and it is not entirely in the nuclear area. They are doing good work in geothermal drilling, for example.

As far as the weapons side is concerned, we did make a joint recommendation to the OMB and to the President and in turn to the Congress that the budget that we have for national security be separate from the budget that we have for energy.

In this way, it would be much more readily brought into the military budget orbit as it is reviewed. We felt that this would be a more sensible thing from an overall review standpoint and we also felt it more sensible from the standpoint of the administrator of ERDA who obviously cannot make a judgment if you are limited in dollars as between, say, a solar energy project and whether to go ahead with a particular weapon development that is requested by the Department of Defense. You can't compare the two judgmentally. They may both be important and you don't want to sacrifice either one.

In any event, I really do agree with your remarks that the universities should be involved and the universities can also participate in the dissemination of information of technology. We are studying that right now at Texas A. & M., for example, in regard to conservation. Eventually we ought to have a mechanism for using—for disseminating all types of technologies.

Senator HATFIELD. Well, I appreciate your comments. And I again say that I think we find ourselves in a difficult role in trying to defend appropriation levels when we are really finding that the OMB is the obstacle between the figures that we have and the administrative request capability, then we have to go find some way beyond the OMB or around the OMB or wait till we get to the floor to have data presented by individual Senators showing the increased levels of spending could be adequately and properly utilized.

We have to find someplace where we can really go, and I think ERDA is put in a difficult role of representing the administration on one hand, with the OMB constraints, and representing scientific research community of its own and outside of its own household, as well, as to a level of appropriate funding.

It is not easy to defend those figures when we get the added information from the floor. And I appreciate your role. But at the same time, I think we have to find a better way to relate funding adequacy to the figures that we are working with in the appropriations committee.

Thank you very much.

Senator GLENN. Thank you.

Dr. Seamans, it is good to see you here again. And on this last colloquy here, I would like to comment on that because I probably have done more amending on the floor or attempted amending than anyone else in the Senate.

I don't think the Senator from Oregon intended those remarks to be aimed directly at me. But, nevertheless—

Senator HATFIELD. If the shoe fits, put it on.

Senator GLENN. If the shoe fits, I will wear it.

But let me say this, that I think that the ERDA budget, quite often, has wound up, through the OMB and the appropriations committee process, butchered from what we had hearings on here and from what we had attempted to do in supporting your efforts over there.

And in every single case where I have gone on the floor and fought for something, it was where the appropriations committee or the OMB had cut your original figures below where we thought they should be.

I have checked with you. I have talked with you or your associates over there and in no case have we ever gone above your original figures to the best of my knowledge.

Now, there may be one exception—photovoltaic, Senator Fannin and I were both involved with it. But all the others that I have fought with on the floor successfully, I am happy to say, because I think they were needed such as the fuel cells, solar energy, and in energy storage. And I don't know specifically what criteria OMB uses. I don't know specifically what criteria the appropriations committee uses, but I think after we have held extensive hearings here, I think we have a pretty good grasp here of what you intended and what the important areas are.

So, I have never exceeded the original request in anything I have fought for on the floor, and I am fully aware and very much in sympathy with the problems that the appropriations committee has in trying to balance off the various needs of appropriations and make sure that the different areas of government and particularly these in energy get a fair shake.

Senator HATFIELD. Will the Senator yield at that point? I think there is one additional factor that I didn't include in my statement and I don't think you have included it either at this point, and that is carryovers from the previous fiscal years.

The appropriations committee has used that as part of its criteria upon making new appropriations and in some of these areas, Senator Glenn, we found that the additions that had been made either by the appropriations committee or by the floor has shown that those moneys were not expended or a percentage of it.

So that was an additional factor that I had left out in my comments that we use as part of our criteria. And, of course, once we approve it either through amendment or otherwise, if they can't spend them, they don't spend them. So it is not a question there, again, of the waste of the money, but it is a matter of whether or not it is over-appropriation.

Thank you.

Senator GLENN. I had two major areas I was planning to get into this morning while you were here. One is the area of conservation that has been discussed, at least in some depth here. I think we need

a lot more effort in that area and I think you probably would agree that conservation is an area where we get the immediate bang for a buck spent in that area. Something that we can conserve now as a barrel saved is a barrel earned, to paraphrase Ben Franklin. And that is the easiest way to get some new supplies immediately. And some of the efforts that have gone on in that area had fantastic results already.

I know everyone in the committee here always starts quoting their home State, but I think you are familiar with the Ohio State University program where they came in and gave us testimony where they have spent money on insulation, and they are getting it back on about a 3-year basis in fuel saved. A fantastic program. I am sorry we don't have that same program going in every government building in this country and every major building in this country. We would save—a fantastic amount, if their experience is any example of what we can do across the country.

I think we have been laggard in not pushing some of those areas. But the other area that I wanted to get into a little bit is in the area of energy storage because this opens up a whole new avenue of running our electrical generating plants, for instance, on a continuing basis or an efficient basis.

Before we are ever going to have solar and some of these other energy sources able to be used on a broad basis, we are going to have to have means of storing them when the sun shines and using the energy at other periods.

The only reason that we are so strapped to gasoline in this country and strapped to crude oil is because it gives us mobility. If we had a suitable electrical energy storage method, we could use it right now, or use it for electrical vehicle transportation.

Now, as a case in point, I come back to the Senator from Oregon's comments. For energy storage last year, ERDA started out with a \$42 million requested in the energy storage area. That was chopped by OMB to \$20 million. In committee here I got it back up to the original ERDA \$42 million. It went over to the appropriations committee and got cut back down to \$20 million something again and I went back on the floor then and finally was out there and got it back up to \$31 million again. So we wound up with at least a chunk of it.

But I think this area of energy storage is important to our mobility, and our ability to use our electrical generating capacities in all periods of the day and night. And we can run our nuclear plants, for instance, at a higher line base load level which would be a big increase right there.

Now this is really a miniscule amount to me to be spending on such an important area that could really redo our whole concept of energy in this country, if we had any breakthroughs in that area. And I would just solicit your comments on how you see this and what efforts you see in the energy storage area going on and whether your funding is adequate there for the state-of-the-art or the state-of-the-research right now. And then I will turn it over to Senator Fannin.

Dr. SEAMANS. Well, Senator Glenn, you have given a, you know, a very good summary of the need for energy storage, and we need to increase our capability. I wholeheartedly concur. It goes all the way from, say, a need to improve electrical storage if we are going to use electric automobiles.

Today the present day batteries are not efficient enough for electric automobiles. We are driving several of them here in the District. The vehicles have a range of about 30 to 35 miles with roughly 1,000 pounds of battery aboard. That is not good. The performance is satisfactory, but it is not efficient to have to carry that weight of battery around.

We are working on advanced concepts for batteries, for example, we have three or four contractors working on it, but a great deal more effort is needed before we will have batteries that can really do the job for, say, transportation of that sort.

It goes all the way up to—and what you have already mentioned—we need to have very large scale storage capacity if we are going to use solar energy or wind energy, energy sources that are cyclic and cannot be relied on hour by hour.

Also from a load leveling standpoint, there is a great desirability for storage. We do have some programs, some studies with utilities. We are looking at the possibility of gas storage, for example, compressed air storage, I should say, in the nighttime and then using that compressed air to take care of peakloads of pumping water uphill and things of that sort.

I think that, myself, from a solar standpoint, chemical storage looks the most attractive at this time. We are just scratching the surface in that area. There is the possibility of magnetic storage of electrical energy. That is much further away in time. We do have some fundamental work going on in that area.

But just to sum it all, efficient storage of energy is absolutely essential and we have a great deal to learn in this area.

Senator GLENN. How about the amounts being spent on this? Even back up to the \$31 million we finally got through in appropriations, in all these different areas, what are you talking about? Magnetic storage? Chemical storage? Battery storage? We haven't even mentioned flywheel storage, pressure devices, change-of-state type storage, or electrolysis which gives hydrogen storage.

All of these are things that it seems to me just splitting up that \$31 million budget, down to \$3 or \$4 million, which is nothing compared to the whole budget. And you could hardly even get started with the program with that kind of an expenditure if it were split up evenly among those areas.

Do you need a serious increase or a major increase in the funding in these areas?

Dr. SEAMANS. Well, I am very gratified that we have the \$31 million—that is half way in the direction of a goal that we recommended, the \$40 million.

I think it is incumbent on us in connection with our budget preparation for next year, for 1978, to do a more thorough job of detailing the plans. I think part of the funding we now have is for that purpose. The planning purposes.

And I hope that we we come back next year we will be much more definitive and we will be able to spell out for you and for the other Members of Congress the need to more rapidly expand in this area.

Senator GLENN. In one specific area, on energy recovery—I know we have talked before several times about the capabilities of regenerative braking on cars and so on. I know it is a pet of mine, but 40 percent of our crude oil in this country goes into the mobility of automo-

biles and the small vehicles, and yet we kill all that energy off—just the heat on brake drums getting stopped. Yet there are all sorts of devices and flywheels and pressure devices and hydrogen generation and things like this that could be used to recoup a little bit of that. Even if we only recoup, say, 10 percent or 20 percent. That is pure gravy, or pure energy, I should say, that we just back for free.

Do you feel that your experiments in this area are leading anywhere? Do you have any up-to-the-minute report you could give us in that area of energy recovery and storage gain?

Dr. SEAMANS. It is interesting that even with the electric vehicle, which lends itself much more readily to storage, that the automobiles that exist today do not use their motors as generators during a braking operation, you know, thereby recharging the battery. We are encouraging the manufacturers to work on that line.

We do have some minimal effort on the flywheel type operation, which, again, lends itself to this mode of operation.

Senator GLENN. Are any private companies actually doing work along these lines now, on regenerative braking?

Dr. SEAMANS. I frankly am not familiar with any work that is going on. Let me submit for the record, after looking into it, a summary of what is going on at this time.

Senator GLENN. Fine.

[Subsequent to the hearings Dr. Seamans supplied the following:]

APPLICATIONS FOR REGENERATIVE BRAKING

A regenerative braking system using a flywheel for storage is being developed under a ERDA contract to AiResearch for recovering braking energy from conventional as well as advanced automobile systems. This system will be fully developed and demonstrated in a vehicle by September 1979.

The Electric and Hybrid Vehicle Systems Office within the Energy Research and Development Administration (ERDA) Division of Transportation Energy Conservation is funding several projects involving the study and/or evaluation of regenerative braking for energy conservation. Three parallel electric vehicle design studies are being conducted by separate contractors, each of which are examining various methods of regenerative braking. One design approach given careful consideration is the utilization of a flywheel for recovering and storing braking energy for reuse during acceleration and hill climbing maneuvers.

A joint project is also being conducted with the ERDA Division of Energy Storage Systems and the U.S. Postal Service to evaluate the performance and energy efficiency improvements that can be achieved by integrating a flywheel into the current electric postal vans for recovering braking energy.

Another activity within the Division of Transportation Energy Conservation includes the testing and evaluation of existing electric and/or hybrid vehicles, some of which utilize various regenerative braking concepts.

Senator GLENN. Another question on this enhanced recovery which you mentioned, which was discussed a little bit when you were going through the slides a little while ago. I think it has been estimated somewhere around we only get out of each oil and gas field—particularly oil, I believe—about 30 or 35 percent of the estimate of what is actually in the ground.

So that is an obvious tremendous area that we can get into. Do you see any breakthroughs in that area of enhanced recovery techniques? Or is this just an ongoing thing—and I have looked at the charts that indicate where you are in those. We are just really into that, just beginning to get into it.

Do you have any consoling words for us in those areas?

Dr. SEAMANS. We have a number of projects. These are jointly funded projects with industry, 8 or 10 of them. The one I happen to be familiar with is down in Osage County north of Bartlesville, Okla. We have been there and walked over the land and have seen what they are doing. The Phillips Petroleum.

There the special solvents that have evolved from the laboratory work where they actually bring up from the subsoil sandstones with the oil in it that is currently lodged in that particular field and tried various solvents and then for the test that we are now running, pumped the solvents down in the ground and then wait. And it takes on the order of a year or so before you can tell whether we have really dislodged a large percentage of the oil or not.

That work is still underway and we are hopeful. If it is successful, the cost of the solvents are pretty high, and it will be necessary to set up some special operations to get the cost of those solvents down.

But that is an effort that hasn't started yet, and it remains to be seen whether the technology is sound or not.

Senator GLENN. Could you comment on how OMB goes about their cuts once the figures leave your shop? And I note that this gets into an interagency type comment here and I don't want to put you in an embarrassing position, but do they call upon you for expertise and guidance because they can't possibly have all the expertise over at OMB that you have in ERDA? When you have made decisions and sent them over there it must be quite disheartening to see the budget come out butchered before we get it at this end of the line.

And we go back and pick up something like the Holloway tables and so on and try and reconstruct something out of what we get and make something that you can live with.

Do they consult with you or do they use their own expertise or what procedure? That has disturbed us on this committee.

Can you comment on that?

Dr. SEAMANS. The discussions with OMB are extensive. The original submission that we make is examined carefully by them. They are divided up organizationally with departmentally or a particular group of examiners that normally look at our budget. Then after they have gone through it, we have our specialist meet with them and explain project by project the value of the effort, as well as the budget itself, whether we are budgeted correctly for that effort.

And they use what I call the ratchet principle which is to sometimes take us down because they claim the project isn't sound and needed and in other times they will ratchet us down because they say, yes; it is a great project, but you don't need all the money for the project.

So I am very familiar with the ratchet process. I have been working with it for 16 or 17 years. And I very much respect the OMB and the job they do, which is to reduce the budget. That is their objective.

Senator GLENN. It is also the thumbscrew technique, too.

Dr. SEAMANS. And then after going through this project by project, there is a series of discussions that involve senior people in OMB. The senior people in the particular agency and finally winds up with an extensive discussion with the director of the budget preparatory to discussions with the President, and what we agreed to do at that time is to agree, where we disagree if you will, agree on those items that we

will take to the President because we feel that they are at a very important policy implication.

Senator GLENN. Let me say that Senator Fannin and I sort of got short shifted on time this morning, but let me say that our relationship in trying to work back and forth with your office has never been anything but on the highest order and you are very cooperative. We appreciate your cooperation personally and the efforts of your staff.

And everytime that we have tried to get information or figures or data, you have been most cooperative over the past, well, ever since I have been here in the Senate. We appreciate that very, very much. It is going to take the best of all of us to work out this whole thing in energy.

I happen to think that we have a bit more of a national energy policy than most people seem to think. It is not all set down in one document, one book. But if you look at the short term things that we are doing and trying to do in this time period of 5, 8, 10 years where we are extremely vulnerable, where we are trying now at last to try and get some new holes drilled in the ground. And while we are going to be dependent on the 82-percent crude and gas that we are dependent upon, we are going to have to get more energy into conservation in that time period. We have to drill every hole we can drill here and offshore both. And that may get us through, if we luck out.

Then once we get on down the road a little bit, you put together all these bits and pieces you have going on future fuels and so on, and I have a great confidence that some of these things will come through and start feeding in and supplementing these oil and gas storages in that time period of, say, 8 or 10 years out here.

So I think that the whole thing fits together as a bit more of a coherent policy than most people seem to think.

Now, whether our intelligence and our luck happen to all dovetail and get us through, both the short and long-term period, I think is—well, the jury is still out on that one. But that is what you are working toward and we have been trying to support you along this, too. Senator Fannin.

Senator FANNIN. Well, thank you, Mr. Chairman. And I would like to concur with the accolades that have just been presented to you, Dr. Seamans, due to the cooperation that you do give to the Congress. My office has been satisfied with your willingness to, at all times, assist when we have problems and to go even further in developing information for us, and it is very much appreciated.

I am just wondering whether or not we are returning those favors. I am afraid that we have placed some barriers in your path of accomplishing some of these programs. I wasn't here—I was in the finance committee because we had some programs on geothermal energy that were being discussed with which I was involved—in fact, I had an amendment. It was necessary for me to be at that meeting.

But I do want to just ask you how we can assist you and to just cover one point. You have talked earlier about the patent problems and what is happening as far as reluctance of some inventors or some corporations or companies that hesitate to go to ERDA on a cost share program because of the fear of losing control of the patents.

Have we, in legislation, adopted some stipulations, that make this more difficult for you?

DR. SEAMANS. No. I think the patent policy has come out quite well. Our enabling legislation called for us to carry out a 1-year study which we did and we then came in with a report to the Congress on our projected patent policy which we also put in the Federal record.

And we are now following it. And it does give us, I believe, a degree of flexibility that is needed. We do respect proprietary information. People can submit proposals to us with proprietary information and we will observe the nature. We will observe the need to keep that under wraps.

When we proceed with going projects—you know it depends on the particular project, but by and large, any patents that come out of that effort we agreed must be licensable by others at a fair price and people seem to be agreeing to that and then any royalties that come out of it in almost every case that we have negotiated go to the private as well as the public, depending on how the cost sharing arrangements were set up.

So it is a very complex subject, but to oversimplify it, I believe it is working out in a satisfactory manner.

Senator FANNIN. Well, I am very pleased to have you say that because I was very concerned from some of the reports I have received that there was a reluctance to utilize ERDA's facilities and certainly we wanted to be advised because of the fear that patents would not be retained. And, of course, I know that government money is utilized, and I would not want it to be one-sided.

At the same time, I think some of the companies feel that they have gone a long way and they need to have a little assistance so they want to be able to go to ERDA for that assistance. I think you have had some people in this week demonstrating a rotary engine. I don't know whether they demonstrated it to you or not, but I know that they were very competent.

They were covered with patents, but they needed to have some assistance in going forward and determining just what could be done with that particular invention. I know that some of the people involved were a little reluctant as to just what rights they might sacrifice if they did accept Federal funds.

DR. SEAMANS. I think there is—you know, all the decisions haven't been made yet. And it remains to be seen if there is a loan guarantee program, exactly what patent arrangements might be required as a result of legislation and this is still a matter that is up for debate.

I am not too familiar with all the specifics on it, but I think we have got to be careful in any new legislation that other restrictions are not placed on ERDA that would make it much more difficult to get companies to participate.

Senator FANNIN. Well, I was thinking of the loan guarantee program specifically when I asked the question because I recall that on the \$6 billion loan guarantee program we sent over to the House, which was not accepted by the House, that we did have stipulations in there that even in a loan guarantee program in which the company would have no obligations remaining, that they did give up some of their patent rights.

And this disturbed me because it would result in companies not utilizing the funds involved. I am anxious for them to go forward with the programs as rapidly as possible. That is where the Federal funding is

most helpful and that is why I am concerned as to just what is done in that regard.

Now, during the consideration of ERDA's 1977 budget authorization, the Senate adopted an amendment placing responsibility for water assessment of an energy project with the Water Resources Council. Does this overlap assessment ERDA is presently equipped to undertake? Do you feel it will hamper your demonstration goals in any way?

Dr. SEAMANS. Well, first, I think that water assessment is very critical to quite a number of different energy endeavors and it is important to have a sound assessment.

Dr. SEAMANS. After checking with the program areas that would be impacted by the Water Resources Council amendment, I have been advised that the amendment without clarifying report language does severely restrict ERDA's flexibility in having water assessments prepared in a time fashion so as not to delay crucial demonstration projects. ERDA's concerns are primarily as follows:

The timing of a mandatory water assessment is ambiguous and premature relative to the project design. The initial phases of a demonstration or commercialization project are devoted to preliminary engineering, including detailed site and environmental evaluations. These studies must be performed before there are sufficient data to prepare a reliable water assessment for a specific site. If the assessment is a prerequisite to Federal assistance for the initial phases of a project, then the assessment cannot be prepared with accurate data. The current language of section 13b and 13c makes the timing of the assessment unclear.

There is less incentive for an outside agency to prepare a water assessment in an accurate, timely, and comprehensive fashion. Failure to prepare a proper report means a project delay or cancellation. Moreover, preparation of the assessment requires advanced energy knowledge and expertise that are best available in ERDA.

The Water Resources Council does not presently possess the staff, the organization structure, or the delegated authority to prepare water assessments for ERDA in a timely fashion. A WRC staff report must be approved by the Council before it can be represented as a product of the Council and hence, as a fulfillment of section 13. The Council, however, meets only quarterly and thus is not readily accessible. The Council consists of selected Cabinet members and the top officials of several other agencies. Draft reports and other matters proposed for adoption by the Council must generally undergo a lengthy review and evaluation by each member agency before that agency's highest official will give his approval. Although there is much expertise in the member agencies of the Council, the staff of the Council is quite small. There is little to be gained by interposing the WRC staff with a veto through inaction on ERDA demonstration projects, but the law as amended in effect accomplishes this action.

In order to provide the flexibility required, ERDA would recommend that the House/Senate conference on the authorization bill include report language that would accomplish the following.

Include language in the ERDA authorization conference report that clarifies the funding limitations contained in section 13(b) and 13(c) apply to expenditure of funds for plant and capital equipment, not operating expenses. This will allow conceptual design, studies, and

data collection to be performed on each proposed demonstration plant but will preclude that start of actual construction until the water assessment has been completed.

The language as now written could be interpreted to preclude any funding for a demonstration project until after the water assessment has been prepared.

Add language in the conference that will allow ERDA to prepare a water assessment on a demonstration project if the WRC has not prepared the required assessment within 45 days after they are provided the data contained in the environmental assessment, or draft environmental impact statement. This will prevent WRC from a "veto" on a project due to inaction.

In the event ERDA prepares the water assessment, it will be sent to the WRC and will be available for public review at least 30 days prior to finalization.

Senator FANNIN. Well, I certainly welcome that you coordinate in government programs. And one program that is of great emphasis to me is the desalinization of solar energy, on which ERDA has been doing some work with the Department of Interior and with the Bureau of Reclamation. I think, specifically, with the water desalinization division.

Is that being carried forward now?

Dr. SEAMANS. I am not really familiar with details. Perhaps I could put something in the record on this, if I might.

[Subsequent to the hearings Dr. Seamans supplied the following:]

ERDA cooperates with the Department of Interior and supports several studies which evaluate desalting technology. The intent is to help develop this technology and help satisfy future fresh water needs for municipal, industrial, and agricultural uses. Combining of power and water plants result in minimum energy utilization for production of both commodities. The studies have focussed on evaluating the coupling of large nuclear power plants to desalting plants, developing cost codes and updated costs, and preparing conceptual designs for specific applications. As part of this effort a preliminary study has been completed of a dual-purpose nuclear plant in Arizona which would produce in the range of 700 to 1,000 MWe and 50 to 250 mgd of desalted water. As solar energy development progresses, it should also become possible to utilize this energy source for desalting purposes.

Senator FANNIN. I would appreciate it because it seems to me it is a tremendously important one when we realize that the Federal Government is going to spend several hundred million dollars in a project where a tremendous amount of energy will be utilized. And it is in an area where there is more sun than anyplace on the earth which happens to be in Arizona. If we could utilize the solar energy for that purpose, it seems to me that it would be an opportunity to prove or disprove what could be done. I think it would be of a tremendous savings to the Government and that is why I am so very desirous of having this carried forward.

We had talked earlier about what is being done. The Senator pointed out what the British are doing. I know it is an attempt to seize around Britain's clothesline. It serves as an inspiration to poets.

And nowadays, a common sharing can be put to use. The British Government has decided that ocean waves are intrinsically more attractive and they go on to say that no attempt is made to compete with the ambitious American research program to divert solar energy directly into electricity.

My question is do we have any repository where information is gathered from around the world to determine whether or not we are taking advantage of all the information that can be obtained?

Dr. SEAMANS. Well, at this time our scientific and technical repository in ERDA is at Oak Ridge. We have a very, very extensive library there if you want to call it that and information retrieval system.

We are attempting to have there a library that covers obviously all manner of energy and not just nuclear, while that is how it got started, but the solar and the geothermal, as well as conservation.

Again, I will have to say that I am not sure to the extent to which we have there information on other than domestic programs, and so let me ask—perhaps Mr. LeGassie has some information.

Mr. LEGASSIE. Yes. Through the International Energy Association in Paris which is 18—I believe now 19 countries who are users of oil internationally which includes the United Kingdom as well as the United States, there is a research and development committee operation which has ERDA representation on it, that gives ERDA access to information as to the assessment processes used by other countries. Their research and development plans, the rationales that they have been using to decide to move in certain directions.

And, in particular, the case of the British decision to go toward waves. I have talked, myself, directly to Dr. Marshall on this. And the point has been made to us that, first, they are prepared to share of their assessment information with us.

Second, that they do not have available to the United Kingdom some of the alternatives that the United States has. Basically, they are looking for something that isn't oil and gas. And in addition to a nuclear program which they also have, they are looking for what one might call the third technology area.

And in this area the United States is moving aggressively in the solar area. And the British climate is not really very susceptible to the use of solar energy. The United States is moving to geothermal and there is no geothermal energy in the United Kingdom.

So, in fact, the things that we have selected as opposed to waves, simply aren't available to the United Kingdom, and they finally come by that process to a situation that the wave power does have some attractiveness to them, particularly because one has to have very high and deep troughs and a very steady wave structure, as they get it, as a result of the waves traversing the Atlantic. And we do not have quite the same situation off our coasts.

We have started some assessment processes nevertheless to look further into whether we should be doing something in this area. But the knowledge transfer in terms of international R. & D. programs is quite operative. And we have been pursuing these kinds of questions.

Senator FANNIN. Thank you very much.

Mr. Chairman, I have been called to the Finance Committee and I have to leave. I very much appreciate Dr. Seamans for being with us today and I will have some further questions, but I just would appreciate, if I could contact you later in that regard.

Dr. SEAMANS. Fine.

Senator GLENN. Thank you, Senator.

Does that ocean study of waves also include tidal?

Mr. LE GASSIE. Yes; there have been studies on tidal, but the conclusion of both the British and the French—the French also have studied tidal and that is that the capital investment required for energy in tidal forces are so enormous that they don't presently appear to be economically attractive.

So the British are really not pursuing the tidal. They are pursuing several different designs of structures which one would actually put out in the ocean which would transform mechanical energy into electrical energy. And this is entirely different from concepts of tidsals.

Senator GLENN. It grieves me greatly to come back and say with all these things, we still need energy storage. I will get that saw in there again. And when we get on that one, I think we are limiting ourselves in solar and thermal gradient and ocean and waves and wind and all sort of things that are of the intermittent operations we would like to take advantage of in solar for use at other times.

Let me ask only one other question here that may be rather basic to your whole operation over there. I know you do a lot of computer modeling and mathematical modeling and made some of your decisions at least on those or most of them I would presume are based, at least to some degree, on those.

It has been my understanding that FEA has had the responsibility the lead agency responsibility in this computer modeling area, and we are trying to tie together energy and EPA and environmental concerns and economic considerations, and so on.

And if this were to convert over to ERDA in about the 1985 time period, how do you coordinate this? That is such a mammoth thing and if you are making very major decisions on this mathematical modeling, who has the sack? Who is responsible on that? And who is doing it? And how competent is it? Does there need to be a better level of coordination between agencies? And do you see yourselves at this time as taking that over if FEA—goes out of existence as it looks now like they will?

Mr. LE GASSIE. Well, I think that we have built up within ERDA a very fine capability in this area and the way the present situation has both evolved and now operates is that when ERDA came into being about 15 months ago, FEA had very detailed models of the economy and of industrial sectors of the country, which were felt to be valid through about the 1985 time frame.

They were only studying the near term because they were concerned only with very near term outputs. And they had models which were in considerably greater detail because of that near term focus.

ERDA brought to the party on its establishment a very fine set of energy and economic models, but which had somewhat less detail with respect to what might happen in the near term, because those models were directed at trying to cover the long term use and to get out into projections and case studies that might go to the year 2000 and beyond.

As a result, a somewhat obvious agreement was reached that FEA would first—that the two agencies would do their work jointly, that is, that they would cooperate and talk continuously to each other about their respective modeling efforts.

Secondly, that FEA would take the lead in activities involving matters before 1985, and that ERDA would take the lead in studies involving modeling which went beyond 1985.

We found that when we independently ran our models and looked at 1985, that we were within 1 percent of each other with respect to work that we had done independently which we tried to project what 1985 might look like.

So, this coming together—and let's say starting with an FEA emphasis in the near term modeling and emerging to an emphasis for the long term modeling did not have to go through any difficult transition not whole because we found that our work matched quite well.

And we have now been proceeding very much to do things jointly so that FEA talks to us about case studies they make that are pre-1985 and we talk to them about case studies we make that are post-1985.

Senator GLENN. With this being so important to your decision-making process, as I presume it is, I presume that you base a lot of your decisions on specifically the outcome of these studies, do you think it would be a good idea to put this in your plan, the ERDA national plan, that is, that you ought to up-date each year? Would it be good to put in the criteria on which you are constructing that model?

Mr. LEGASSIE. Well, we have tried to include some information of that kind in the appendices to the document. A lot of this information is highly technical and highly detailed and is published in other documents which are available.

Now, what we did in the current 1976-1 was to give the specific references in the back to the other documents where one could obtain—

Senator GLENN. Is the model construction fully available?

Mr. LEGASSIE. Oh, yes. We have made this available to State governments, for example. A particular example, the California Energy Commission had approached us and wanted to use some of this capability. Various private companies have access to this so that the work is fully available, both for review, peer review as to its accuracy, and for others to perhaps carry on and to do their own type of examination.

Dr. SEAMANS. And under one aspect of this turned out very favorably, I think, is that through the International Energy Agency we reviewed our studies with the other 17 nations and they, in turn, felt that this would be helpful to them to have similar studies carried out on their own energy situation.

We set up two locations, one in Germany and the other in Brookhaven up in Long Island, with the same programing and the member nations are now in the midst of their energy studies.

We hope that by doing this we are providing a service that we believe will be helpful to them, but we also hope that we can then aggregate the information and we will have a total energy picture that will also be valuable.

Senator GLENN. I know you came to testify primarily on the 1976 ERDA plan here this morning, but let me ask you one other question

that is related in a way because I know you have thought about it. I am sure you have thought about it at some length.

We have different agencies and different energy-responsible agencies still spread around quite a bit. There is ERDA and there is NRC and there is FEA, and there is all the different things.

And there has been talked about it being proposed that we establish a Department of Energy and Natural Resources which would bring these altogether under one roof finally and one direction and coordinate much more of the overall policy.

Would you care to comment on whether you favor or are against the establishment of a Department of Energy and Natural Resources, whatever it might be brought under, but just as a general principle, which I think you are familiar with?

Dr. SEAMANS. Well, as I know you are aware, we are currently reviewing just this question under the aegis of Elliot Richardson and Jim Lynn and looking at the various commendations and permutations, I still certainly don't think we will achieve the millennium as far as energy organization is concerned either in the executive branch or in the Congress.

Senator GLENN. I will second that.

Dr. SEAMANS. I am very hopeful that this is now more generally recognized and we can improve ourselves organizationally on both sides of the fence.

As to whether you need to have it at the departmental level, I guess I have not quite made up my own mind. I think it does need to have stature. I think it does need to have status, as I see it. Those involved in this work need to have, you know, good access to the inner circles of government, if you will. And I think those who are responsible for running the government need to be well informed in this area.

So I think what you have raised is a good question and I think at the moment I will just plead nolo.

Senator GLENN. I hope, Dr. Seamans, and the other people you have here from ERDA would be willing to answer any further written questions the committee may submit. I have enough just lined up on my own pad to take care of the whole afternoon if we stayed here and talked about them.

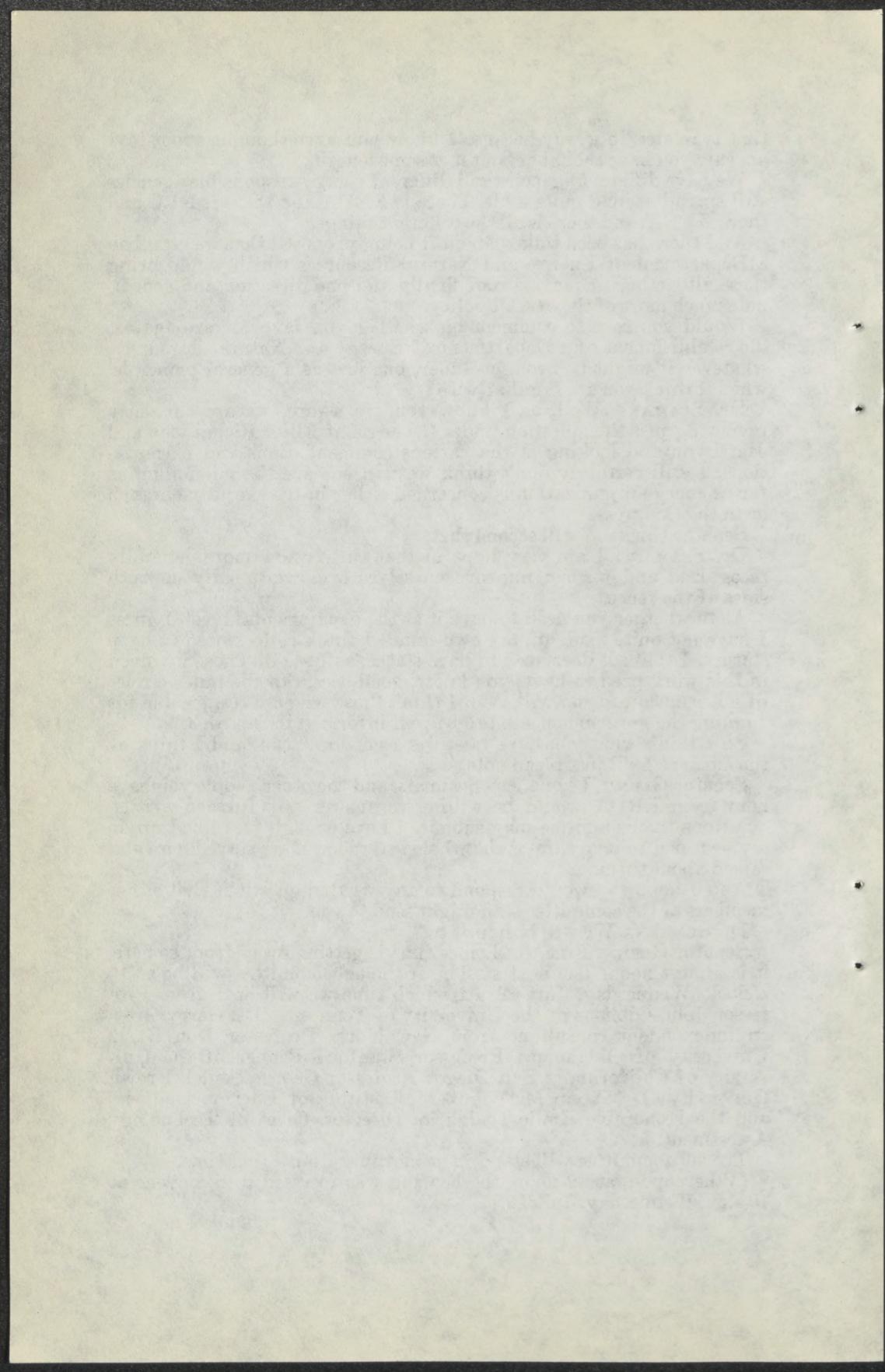
And I hope you would respond to any written questions that either members or the committee staff might send to you.

Dr. SEAMANS. We will be happy to.

Senator GLENN. Fine. And since time is getting away from us here, it is almost noon. The next session of the subcommittee will be at 10 o'clock, Wednesday, July 28. At which time we will hear from Professor John Gibbons of the University of Tennessee, Dr. Gerry Grey, an independent consultant from New York, Professor Don Kash, University of Oklahoma; Professor Stanford Penner of the University of California at San Diego; Professor George Seidel, Brown University; Dr. Alvin M. Weinberg, Institute of Energy Analysis; and the Honorable Emilo Daddario, Director, Office of Technology Assessment.

The subcommittee will stand in adjournment until that time.

[Whereupon, at 12 noon, the hearing was recessed to reconvene at 10 a.m., Wednesday, July 28.]



ERDA LONG-RANGE PLAN AND PROGRAM

WEDNESDAY, JULY 28, 1976

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND WATER RESOURCES,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 3110, Dirksen Office Building, Hon. Dale Bumpers presiding.

Present: Senators Bumpers and Haskell.

Also present: Ben Yamagata, counsel; and Christopher Coccio, science consultant to the committee.

OPENING STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator BUMPERS. The subcommittee will come to order.

This hearing marks the second day in a set of hearings conducted by the Subcommittee on Energy Research and Water Resources to examine the ERDA long-range plan and program.

More specifically, we hope to examine the goals established by ERDA's plan and the assumptions made by the agency in formulating the direction of our Nation's energy research, development and demonstration effort.

If ERDA is to have the full support of the Congress in the important job assigned to that agency, then it is incumbent upon the Congress, and this oversight committee, to examine the plan and to provide guidance in the development of alternatives to energy supply and demand.

While recognizing the necessity for research and analysis, this committee is interested in seeing results. Indeed, our growing dependence on foreign oil which is siphoning off more and more of our dollars, necessitates an energy development program that is result oriented. Where and how ERDA invests its funds will largely determine how soon we get results. I hope that our witnesses this morning can help in this vital area of inquiry.

While acknowledging the fact that the development of energy alternatives will be costly, this committee intends to assist in making the final decisions about the total commitment to be made in each non-nuclear technology area. Yet, it is difficult to do that if ERDA's plan does not include projections on the actual, ultimate costs of various programs.

Finally, while sympathetic to the difficulty of predicting the degree of success or failure in each of the energy R. & D. programs, it is imperative that this committee be able to judge yearly how successful ERDA has been. In other words, we need some benchmarks against

which we can judge ERDA's program and its performance. The plan does not include such information.

Today's witnesses are uniquely qualified to help us in examining the major program areas in ERDA and addressing these broad issues I have just mentioned. Our witnesses have each participated in several studies by the Office of Technology Assessment in which the ERDA long-range plan has been critiqued.

I want to welcome you here this morning, gentlemen, and to thank you for coming.

Our first witness is Hon. Emilio Daddario, Director of the Office of Technology Assessment. I will leave it to you to decide the order of testimony.

Senator Haskell, do you have a statement?

Senator HASKELL. No.

STATEMENTS OF HON. EMILIO Q. DADDARIO, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT; DR. DON E. KASH, UNIVERSITY OF OKLAHOMA; DR. GEORGE SEIDEL, BROWN UNIVERSITY; DR. ALVIN M. WEINBERG, INSTITUTE OF ENERGY ANALYSIS; DR. JERRY GREY, INDEPENDENT CONSULTANT; DR. JOHN H. GIBBONS, UNIVERSITY OF TENNESSEE; DR. STANFORD S. PENNER, UNIVERSITY OF CALIFORNIA AT SAN DIEGO; ACCOMPANIED BY DR. RICHARD ROWBERG, OTA STAFF; AND LIONEL S. JOHNS, OTA STAFF

Mr. DADDARIO. Thank you, Mr. Chairman.

First of all, I would like to introduce the panel chairmen who are with me here this morning, and have participated in the analysis of the planning program.

From my left to right, Prof. Stanford Penner, Dr. Jerry Grey, Prof. Don Kash; to my immediate right, Prof. John Gibbons, Prof. George Seidel, and Dr. Alvin Weinberg.

Congress mandated annual submission of a plan and program in order to enhance oversight of ERDA's complex tasks of providing options and solutions to national energy problems. Early in 1975, OTA was asked by Congressman Teague and by Senator Jackson to provide a detailed analysis of the research and development plans of the Energy Research and Development Administration.

The first step in this process was an analysis of the fiscal year 1976 budget which was performed by OTA in February 1975. This was followed by an analysis performed during the summer of 1975 of the first ERDA plan and program, ERDA-48.

This phase of the analysis was completed in October 1975. In February 1976, OTA completed the study by carrying out a comparative analysis of the revised ERDA plan and program in relation to the findings of the analysis of ERDA-48.

The analysis of the fiscal year 1976 ERDA budget was performed by a task group made of individuals familiar with the range of energy technologies and who represented a balance of viewpoints on the Nation's energy R. & D. needs. For the evaluation of the ERDA plan and program, task groups were assembled in each of the ERDA pro-

grammatic areas, and the gentlemen with me were chairmen of these task groups:

One, Fossil energy; two, Nuclear energy; three, Solar, geothermal, and advanced technologies; four, Conservation; and five, Environment and health.

Participating authorities were drawn from major manufacturing and energy industries, utilities, universities, public health disciplines, environmental protection groups and professional engineering, architectural, and legal societies.

For the analysis of ERDA-48, the five panels addressed specific aspects of energy development and demonstration in weeklong sessions starting in early July 1975. A sixth overview panel, which included the chairmen of each of the five technical groups, was assigned the task of providing a coordinated overview. Backing up this effort were three major universities: the University of Oklahoma, the University of Texas, and the Massachusetts Institute of Technology.

The task force for the comparative analysis divided into subpanels for each of the programmatic areas and met as a whole to examine the overview issues. This study was published in May of this year.

In carrying out the comparative analysis, OTA was assisted by members of the center for energy studies of the University of Texas at Austin and the science and public policy program of the University of Oklahoma.

Present with me today are the chairmen of the subpanels: Dr. Don Kash, overview; Dr. George Seidel, fossil fuels; Dr. Alvin Weinberg, nuclear; Dr. Jerry Grey, solar, geothermal, and advanced systems; Dr. Jack Gibbons, conservation; and Dr. Stanford Penner, environment and health.

They will represent their various subpanels and will be pleased to answer any questions you have. In addition, from the OTA staff I have Mr. Lionel Johns, the energy program manager, and Dr. Richard Rowberg, project leader for this analysis.

Rather than to continue the statement, I would now like to introduce Dr. Don Kash, chairman of the overview panel, for his testimony this morning.

[A short biography of subpanel members follow:]

DR. DON KASH, OVERVIEW SUBPANEL, DIRECTOR, SCIENCE AND PUBLIC POLICY PROGRAM, UNIVERSITY OF OKLAHOMA

Dr. Kash is also the George Lynn Cross Research Professor of Political Science at Oklahoma where he has been since 1970. Prior to that he was an Associate Professor at Purdue University. Dr. Kash has been involved with public policy activities for a number of years and has testified before Congress a number of times on energy R&D and offshore petroleum development. Dr. Kash received his B.A. from the University of Iowa in 1959 and his Ph.D. from there in 1963.

DR. GEORGE SEIDEL, FOSSIL FUEL SUBPANEL, PROFESSOR OF PHYSICS, BROWN UNIVERSITY

Dr. Seidel has been at Brown University since 1962 after spending three years as a Research Fellow at Harvard. In addition to his position at Brown, Dr. Seidel served as a member of the APS Summer Study on "Efficient Use of Energy: A Physics Perspective" and served with the OTA staff during the summer of 1975 on the preparation of the analysis of ERDA-48. Dr. Seidel received his B.S. from Worcester Polytechnic Institute in 1952 and his Ph.D. from Purdue University in 1958.

DR. ALVIN M. WEINBERG, NUCLEAR SUBPANEL, DIRECTOR, INSTITUTE FOR ENERGY ANALYSIS, OAK RIDGE ASSOCIATED UNIVERSITIES

Dr. Weinberg served as Director of the Energy Research and Development Office at the Federal Energy Administration. Prior to that he was Director of Oak Ridge National Laboratories for a period of 19 years. He received his A.B., A.M. and Ph.D. from the University of Chicago.

DR. JERRY GREY, ADVANCED SUBPANEL

Dr. GREY is now Administrator of Technical Activities for the American Institute of Aeronautics and Astronautics, where he spends half of his time. The remaining portion is devoted to consulting, writing and lecturing. Previously he was a professor in the Department of Aerospace and Mechanical Sciences at Princeton University for 15 years. Dr. Grey received his Bachelor's and Masters from Cornell University, and his Ph.D. in Aeronautical Engineering from the California Institute of Technology.

DR. JOHN H. GIBBONS, CONSERVATION SUBPANEL, DIRECTOR, ENVIRONMENT CENTER PROGRAMS, UNIVERSITY OF TENNESSEE

From September 1973 to September 1974 Dr. Gibbons served as Director of the Office of Energy Conservation at the Federal Energy Administration. Prior to this he was with Oak Ridge National Laboratory. He received his B.S. from Randolph-Macon College and his Ph.D. in Nuclear Physics from Duke University.

DR. STANFORD S. PENNER, ENVIRONMENT AND HEALTH SUBPANEL, DIRECTOR, ENERGY CENTER, UNIVERSITY OF CALIFORNIA, SAN DIEGO

Dr. Penner previously served as Chairman of the Department of Aerospace and Mechanical Engineering Science at the California Institute of Technology. In 1963 he was Director of the Research and Engineering Division at the Institute for Defense Analyses in Washington, D.C. He received his B.S. from Union College, and his M.S. and Ph.D. from the University of Wisconsin.

STATEMENT OF DR. DON E. KASH, UNIVERSITY OF OKLAHOMA

Dr. KASH. Mr. Chairman, members of the committee, the overview panel of the analysis of ERDA-48, last year's program and plan, identified 16 issues which expressed the major deficiencies in the original ERDA plan and program last year.

In the previous testimony, the two principal overview issues were identified. Here I would like to touch upon some of the other overview issues and the extent to which ERDA addressed those issues between the 2 years that it put together plans and programs.

Last year, the overview panel determined that ERDA was paying only limited attention to socioeconomic research and analysis in addressing the Nation's energy problem. The comparative analysis of the revised plan and program indicated that significantly greater emphasis is being placed in this area and such analyses are being incorporated in each program area.

In addition, we found that environmental considerations are receiving a much higher priority with environmental review becoming a major part of the ERDA planning process.

Second, the overview panel of the ERDA-48 analysis indicated that ERDA had not adequately addressed the development of effective commercialization policies.

This has been remedied to some extent in the revised plan as evidenced by ERDA's establishment of the office of commercialization whose responsibility is to develop commercialization strategies. Al-

though an important first step, we are not yet able to judge its effectiveness.

I might say at the point the second year review took place, we had early drafts of the ERDA plan and program and the prepared testimony represents what was available. Certainly, I and each of the members of the panel would be willing to comment on the individual perceptions that have taken place, but at this stage of the game I want to make sure this represents the view of the overview panel, and there are at least observations I have as an individual.

Third, last year the panel determined that ERDA placed insufficient emphasis on international considerations. In the comparative analysis, we found evidence from the revised plan and program of greater emphasis in this area. In particular, each program area describes international activities related to its various projects.

Fourth, in the analysis of ERDA-48, the overview panel stated that ERDA's planning and management structure could hinder achievement of its goals. In the revised plan and program, we determined that ERDA is taking positive steps to increase its planning effectiveness through the establishment of its planning, programming, budget, and review system to establish R. D. & D. priorities and strategies.

While the comparative analysis task force felt that these represented substantial accomplishments, we also noted that unresolved points remained with each of the issues. I will highlight the major areas of concern here.

One, there remains limitations with the conservation program which could seriously reduce its potential contribution. ERDA appears to have virtually ignored the long-term, lasting potential of energy conservation by excessive concentration on its near-term impact.

Two, a gap remains between the scope of the basic research program and the needs of the energy technology programs. The basic research program remains weak in a number of important energy-related fields such as heat transfer, thermodynamics and combustion processes.

Three, nonelectric energy technology development is still under-emphasized. The OTA overview panel does not imply deemphasis on electrification technologies but we believe it to be desirable for ERDA to place greater emphasis on technologies for direct thermal use of solar and nuclear energy sources.

Fourth, interaction between ERDA and Federal energy-related regulatory agencies needs definition. Because of the profound effect that regulatory agencies have on energy resource development, delivery, and use, they will strongly influence the implementation of ERDA's R. D. & D. program. Therefore, the panel felt that effective ties should be developed between these agencies and ERDA.

Mr. DADDARIO. The next witness is on fossil fuel, Dr. George Seidel.

STATEMENT OF DR. GEORGE SEIDEL, BROWN UNIVERSITY

Dr. SEIDEL. Mr. Chairman, the fossil fuel panel identified 16 areas of concern in the analysis of ERDA-48. The comparative analysis of ERDA 76-1 found ERDA to be generally responsive to the concerns through the proper application of funds and intensified efforts.

Contingencies, due in large part to the lack of a clear national directive for commercial development of currently available and future

fossil fuel technologies, have caused certain lingering deficiencies in the program.

First, I will summarize the more important issues showing substantial ERDA improvement over the previous year.

One, the unrealistically optimistic projections in ERDA-48 for energy supplies in the near term derived from fossil energy technologies have been substantially lowered in ERDA-76-1.

For example, the estimation of 5 quadrillion Btu of energy by 1985 from synthetic liquid fuels from coal has been revised downward to 3.8 quadrillion Btu only by the year 2,000. In general, the objectives of the fossil energy programs are more realistic and the strategies better articulated, such as the synthetic liquid fuels program, which appears balanced with a clearer recognition of technical feasibility and potential.

Two, ERDA has responded to the criticism that its earlier program did not recognize the value of integrated low-Btu gasifier, combined-cycle powerplants.

ERDA-76-1 describes the development of a coordinated program of activities consistent with the potential of this technology for becoming one of the best methods of using coal efficiently, economically and in an environmentally acceptable manner. Further, the application of low-Btu gasification for industrial use, previously not given sufficient attention by ERDA, is now recognized by an effective program.

Other concerns identified in the analysis of ERDA-48 were found to be unresolved in ERDA-76-1.

One, in the area of primary oil and gas recovery, the ERDA-48 analysis identified the need for a comprehensive Federal research program for primary oil and gas recovery from new sources.

In particular, last year's panel highlighted the importance for research on the effects of offshore drilling and for comprehensive studies aimed at resolving institutional and environmental issues.

Furthermore, Congress has mandated that ERDA explore methods for the prevention and cleanup of marine oil spills. While ERDA expresses the need to initiate advanced exploration and extraction techniques both onshore and offshore, no details or budget are apparent in their program.

Also, no work is indicated to improve oilspill cleanup technology or to provide satisfactory answers to other environmental and institutional issues that tend to stifle adequate development. ERDA's response is so limited in funding and focus as to make near-term contributions in overcoming delays unlikely.

Two, the ERDA-48 analysis signaled that enhanced oil and gas recovery could contribute significant quantities of oil and gas in the short run. The comparative analysis showed that ERDA's program and budget were not commensurate with the near-term energy recovery that is possible.

Three, the ERDA-48 analysis identified a need for an oil shale demonstration program based on available technologies. The budget was not responsive to demonstration of the leading technology of "mining plus aboveground retorting" perhaps due to the failure of the commercialization program.

An ERDA-initiated demonstration facility under Federal control remains an appropriate means of obtaining the necessary information

without making an irreversible commitment to large-scale development before the consequences of such a development are known.

Four, in the field of high-Btu coal gasification, the ERDA-48 analysis pointed out that construction and operation of a first-generation, commercial-sized, high-Btu gasification plant was prerequisite to any decision on a coal-based synthetic natural gas industry.

The comparative analysis showed that ERDA's program, and budget remained focused solely on the development of second-generation technologies which, while important, are not central to the problems facing the development of a high-Btu gasification industry today.

Mr. DADDARIO. Next is Dr. Alvin Weinberg.

STATEMENT OF DR. ALVIN M. WEINBERG, INSTITUTE OF ENERGY ANALYSIS

Dr. WEINBERG. Mr. Chairman, the Nuclear Panel of the ERDA-48 analysis identified 18 issues which covered the major concerns with ERDA's nuclear program. As evidenced in the comparative analysis recently completed, ERDA has resolved several of the issues that were raised last year. With others, however, its response seems inadequate to insure the development of potentially desirable technologies.

I would first like to review those major points where the nuclear subpanel of the comparative analysis felt ERDA has made progress.

One, in the analysis of ERDA-48, the panel pointed out the need to enhance efforts in nuclear waste disposal and safeguards.

Perhaps I should interject a personal note. The great nuclear debate going on in this country centers around these two issues.

Senator BUMPERS. I hate to disturb the format, but that is such a critical problem. What have they done? You say they have accorded these areas a new sense of urgency and substantially increased funding. How much increased funding is there?

Dr. WEINBERG. The funding for 1977 is scheduled to be \$82 million for waste disposal. It was \$15 million. That represents a fivefold increase.

I might say my own view about waste disposal—and I have been in the business for many, many years—is that it is really a problem that can be resolved with relatively small amounts of money. It is mainly the question of having the will to go ahead and do it.

Senator BUMPERS. We will explore that a little more in depth.

Dr. WEINBERG. As far as the safeguards are concerned, which is a much more difficult thing in my view than waste disposal, it has gone to \$21 million in 1976 and \$38 million in 1977.

The revised plan and program shows that ERDA has accorded these areas a new sense of urgency and substantially increased funding.

The whole nuclear adventure that must be moved to breeder reactors in 30 or 40 years. Therefore, we were very pleased the subpanel found ERDA has enhanced this effort as appears to be appropriate. It has gone from 12 million in 1975 to 42 million in 1977.

Two, the original analysis indicated that a more timely and accurate definition of uranium resources was needed than was being provided. The comparative analysis subpanel found that ERDA has enhanced this effort as rapidly as appears to be appropriate.

Three, the OTA analysis of ERDA-48 declared that fission fuel recycling capability is needed for the orderly development of nuclear power. In the revised plan and program, the nuclear subpanel found that ERDA has greatly expanded their efforts in this area and seems determined to do whatever is necessary in order to insure an operable system.

With regard to those issues to which ERDA has made little response, there are a few items which seem particularly crucial and deserve consideration. I would like to summarize these points here.

One, in the original analysis, the panel declared that a strong effort was warranted to continue improvement of the light-water reactor technology since our entire short-term nuclear option depends on its success. From the revised plan and program it is apparent that ERDA has a strong interest in doing just this, however, program definition is only beginning to emerge.

Two, there remain in the revised plan and program no serious plans to study nuclear energy centers for the liquid-metal fast breeder reactor. The panels for both of the OTA analyses believe this to be a crucial issue and that ERDA should launch a serious examination of LMFBR co-location.

In my own personal view, I believe this issue may be one of the most important long-term issues facing the whole perception and strategy with respect to the future of nuclear energy. I think we are shortly going to be at a turning point at which we are going to have to decide whether the siting policy, which has been less acceptable for the current generation of reactors, is going to be the same siting policy we are going to adopt. I cannot impress on you how much I personally view this particular issue.

At the time we made the study of the earlier plan, we could see no serious plans to study this issue in the ERDA planning document. This was, you remember, a responsibility of the Nuclear Regulatory Commission. Since this has been written, ERDA has put money into this study, and I say I personally—and I believe I speak for the members of the nuclear panel—agree this is something ERDA should do, and I am pleased to see they are doing it.

Three, the panel evaluating ERDA-48 expressed the view that work on the molten salt breeder was not sufficient to adequately evaluate the program.

ERDA has now dropped the program completely and it is our view that this is unfortunate as it deprives the country of a totally different approach to a breeder reactor which presents quite different technical solutions to many of the problems of nuclear energy.

Four, the analysis of ERDA-48 pointed out that the fusion program may have narrowed its focus too much by its heavy concentration on the tokamak concept. From the revised plan and program it is apparent that there will be continued concentration on the tokamak with major efforts being initiated on the tokamak fusion test reactor.

This will leave even less opportunity to explore alternate fusion concepts at present budget levels. A decision of how broad the fusion program should be would be greatly facilitated by clarification of the priority of fusion among alternate energy options for the future.

Mr. DADDARIO. Mr. Chairman, the solar, geothermal, and advanced systems testimony will be given by Dr. Grey.

STATEMENT OF DR. JERRY GREY, INDEPENDENT CONSULTANT

Dr. GREY. Mr. Chairman, the solar, geothermal, and advanced systems panel of the ERDA-48 analysis had identified in its review last summer 17 issues which described the major deficiencies in ERDA's solar and geothermal programs.

The comparative analysis of ERDA-76-1 and the fiscal year 1977 budget performed this past winter found that the ERDA solar program has made some improvements in addressing these issues, although much remains to be done. The geothermal program, on the other hand, has made substantial strides in treating the issues raised by OTA. In describing these categories, I would first like to summarize those areas where we feel ERDA has made progress since our first analysis.

One, in the first study, the solar panel determined that there was need for improved decisionmaking criteria in selecting R. D. & D. priorities. The revised plan and program showed that steps are being taken to develop such a process although no judgment as to their effectiveness can be made at this time.

In one crucial area, it appeared to us that decisions on high-risk projects, such as ocean temperature thermal conversion, are under better scrutiny than last year, but ERDA has yet to establish a satisfactory methodology for making such decisions.

Two, the comparative analysis solar subpanel found that ERDA is paying greater attention to the nontechnological aspects of solar energy in the revised plan and program than they did last year. This is evidenced by ERDA's increased emphasis on incentives in its solar heating and cooling program.

Three, in the analysis of ERDA-48, the solar and geothermal program did not adequately address the important institutional and legal questions of geothermal resource development. In the comparative analysis, we found that this issue is very well treated with such studies being made an integral part of the entire geothermal effort.

While noting these improvements, the comparative analysis subpanel determined that significant difficulties remain with the solar program. I would like to highlight those at this time.

One, the major criticism of the ERDA-48 solar program was the underemphasis of solar heating and cooling relative to solar electric technologies. Although this remains an issue, it appears to be due primarily to the administration's budget request, since ERDA itself presented a program with a better balance between the two areas.

Two, the analysis of ERDA-48 indicated that the ERDA solar program's heavy reliance on outside organizations and Federal laboratories for program management could lead to an inefficient program and administration.

The revised plan and program showed that no change in the program management structure has been made, apparently because of the limited number of personnel in the Solar Energy Division. Again, this problem seems traceable to the administration budget request, which sharply trimmed the number of personnel in ERDA's recommended program.

Three, there has been little change since last year in ERDA's inadequate basic research program, both in the coverage of nonnuclear subjects and in enhancing the interaction between the basic science func-

tions and the engineering, nontechnological, and commercialization functions.

Four, although the standards and incentives components of the solar heating and cooling subprograms have received increased emphasis, the revised plan and program revealed no systematic means for integrating them into the solar program and for assisting in their implementation.

Mr. DADDARIO. The conservation panel is next, Mr. Chairman. Dr. John Gibbons will testify.

STATEMENT OF DR. JOHN H. GIBBONS, UNIVERSITY OF TENNESSEE

Dr. GIBBONS. Mr. Chairman, in the analysis of ERDA-48, the conservation panel identified 18 issues which expressed their concerns with the ERDA conservation program. In carrying out the comparative analysis of the updated document of ERDA-76-1, we found that ERDA has been responsive to many of these issues.

I would like to summarize, at this time, those issues and ERDA's response which we consider to be most important.

One, the conservation panel, which analyzed ERDA-48, determined that ERDA's conservation effort did not display the sense of urgency commensurate with its potential contribution to solution of the Nation's energy problems.

The comparative analysis subpanel found that the revised plan and program presented a more vigorous approach to conservation in raising its R. & D. priority equal to that of the highest supply options.

Two, in the analysis of ERDA-48, the panel found that insufficient attention was being given to nontechnological constraints which could impede the implementation of energy conservation technologies.

In reviewing the revised plan and program, we found that ERDA has significantly increased their efforts to deal with the social, political, economic, and environmental issues in this area.

Three, the ERDA-48 conservation panel indicated that ERDA needed to establish close cooperation with Federal, State, and local agencies, and the private sector if their conservation effort was to be successful.

The comparative analysis subpanel found that ERDA has placed greater emphasis on interaction with the private sector, particularly the information dissemination and technology transfer areas.

The comparative analysis subpanel also noted that a number of deficiencies remain in the conservation program. I would like to summarize those at this point.

One, although raising the priority of conservation, the budget request for fiscal year 1977 does not reflect this priority, it represents 3.8 percent of the total ERDA energy R. D. & D. budget compared to 3 percent for fiscal year 1976.

Two, the conservation program still includes subprograms directed at storage and delivery of energy as well as those aimed at end-use efficiency.

This creates a distortion which makes it difficult to evaluate each category and gives the appearance of greater effort in conservation than there actually is.

Senator BUMPERS. Every time they mark up their budget, I don't think it ought to be in the conservation area. It should be isolated out, so you could get the results from each one. For example, I see efficiencies as one thing and conservation as something else.

Is that what you are trying to say here?

Dr. GIBBONS. Our feeling is it would be helpful to sort these out more explicitly so one can see where the emphasis is being placed.

Senator HASKELL. Suppose you eliminated from the conservation portion of the budget the subportions you allude to; what then would the percentage of conservation be in the total budget?

Dr. GIBBONS. I believe the figure would be about 2 percent.

Senator HASKELL. Assuming your observation and the chairman's observation are both accurate, then really ERDA is only spending 2 percent nationally. We are spending a 2 percent commitment to our energy conservation.

Dr. GIBBONS. That is correct.

There, the conservation program is oriented too much toward the near term—to 1985. Little research is underway on innovative conservation technologies with the potential for high payoff in the long term.

Four, the conservation program has no apparent fundamental sense of direction. A conservation strategy needs to be articulated so the program elements are viewed as parts of a whole.

Mr. DADDARIO. Dr. Stanford Penner.

STATEMENT OF DR. STANFORD S. PENNER, UNIVERSITY OF CALIFORNIA AT SAN DIEGO

Dr. PENNER. Mr. Chairman, the revised ERDA program for environmental research and safety represents a significant improvement over the planning and implementation program submitted in ERDA-48.

Comparison of the descriptive text of ERDA-76-1 and ERDA-48 indicates significant changes, at least in intent, on the part of ERDA. In my remarks today, I will present our findings on the progress made by ERDA in responding to the 14 issues which the environment and health panel identified relative to ERDA-48.

The ERDA program structure in the general area of health effects is a significant example of ERDA's recognition of issues raised in the OTA analysis, though in some cases the ERDA response may be simply a matter of more thorough description of pre-existing programs.

One, for example, an issue originally raised concerning research on sulfate air pollution is now well-addressed in the health effects, environmental effects and physical and technological studies programs in the larger context of fossil fuel pollutants.

The program is well-characterized and will effectively define the magnitude and nature of sulfate problems from stationary sources.

Two, in another context, a general fault found with ERDA-48 was that there was no integration of environmental or health-related work into ERDA's technology development programs.

The electrical transmission area in ERDA is an example of at least partial integration of these two activities. ERDA personnel have

stated that the results of health and environmental research will not be available in time to affect the design or equipment testing programs planned in electrical transmission technology R. D. & D., but they note that the results would certainly affect deployment of the technologies if deleterious effects are identified.

In some previously identified issue areas, there are significant new efforts which address those issues.

One, new, or at least significantly increased efforts are evident in research on the social impacts of energy production and in development of cooperative programs of information transfer and solicitation of public opinion.

The newly organized and budgeted program on energy and environmental policy considerations recognizes the need for social and other nontechnological research in achieving ERDA's goals.

Two, ERDA was faulted in the first OTA analysis for having too narrow and deterministic an approach to modeling of environmental impacts of its proposed technology programs.

Extensive new efforts by ERDA have been identified in development of new models, analysis of appropriate models developed by other agencies, and expansion and improvement of standardized data bases.

Regrettably, not all the issues originally identified in the environment and health area have been so well dealt with. In several respects, much remains to be done.

One, the original analysis of ERDA-48 resulted in a finding that ERDA was neglecting both systems considerations on water availability in resource rich but water poor river basins, and potential climatic consequences of extensive deployment of new energy generation or conversion facilities.

The more recent analysis of ERDA 76-1 showed that ERDA's program only partially addresses the problem of water demands, and concentrates most of its concern on nuclear power plant cooling.

Competition between energy and nonenergy, and between different energy activities has not yet been addressed by ERDA. Development of integrated regional plans do not yet serve as the proper focal point for ERDA's development plans.

In the area of climate modification by the release of waste heat or atmospheric pollutants, no budget or substantive program activity could be identified in any of several research or cooperative program activities which would bear on this problem.

This is an important program. There is a good deal to be said about this, but I will not dwell on it at this time. But the OTA concerns are now receiving serious response.

Two, in general, the budget for biomedical and environmental research is not keeping pace with the growth of the total ERDA program.

The BER budget for 1977 grew only 4.7 percent, which probably will not keep pace with the inflation rate, while the overall 1977 ERDA budget increased 31.9 percent relative to 1976.

In one area which the OTA analysis identified as critical, education and training of environmental and especially health research personnel, the programs which were deemed to be totally inadequate to start with, sustained budget cuts approaching 40 percent for 1977.

It is difficult to understand how ERDA will in fact achieve its stated intentions in the environmental, health and safety area with the budget request which was submitted to Congress for this work.

Mr. DADDARIO. Mr. Chairman, as we proceed from this point, because they may be involved in the discussion, I would like to introduce to you and the committee, Mr. Lionel Johns who is the program manager for the energy activity in OTA, and to his right, Dr. Richard Rowberg, who was in charge of this particular project.

Senator BUMPERS. Gentlemen, let me say, first of all, in the 11½ years I have been in the Senate, this is the most distinguished and impressive panel we have ever had here. I sincerely regret every member of the Interior Committee could not be here this morning, and I regret even more we have never learned in the Congress to do things like this before we markup the budget bills.

We have the cart before the horse here. Obviously, if a plan had been submitted and we had an opportunity, we would have been much better informed in marking the budget and establishing priorities.

I want to thank you for the work you have done and for coming here this morning, and I want to extend my opening remarks by saying I have been most impressed by all of the comments that have been made here this morning. As I say, I regret very much we have not had an opportunity to do this before we marked up a \$61½ billion budget.

Let me ask the panel this general question. One of the things, of course, that has troubled me—there are a number of things—but one or two major things that have troubled me about ERDA's whole approach to this, that the plan does not quantify what they hope to achieve toward a national goal.

It occurs to me, if we are going to be asked on an annual basis, and we are to continue appropriating money for the various directions they are going, we are going to almost have to have an annual and not more than a biannual quantification of results.

The second thing that has troubled me deals with the apparent phlegmatic approach to conservation. The statistics that were given here and elicited by Senator Haskell from Professor Gibbons a moment ago are really staggering to consider only a 3.8 percent of the total budget is now allocated to conservation, and that includes efficiency such as electrical transmission which I think is one of the things listed under conservation.

You take all of those out and leave 2 percent for conservation. It is no wonder those people are not really sensitive any longer to a growing problem.

Finally, I might make a third observation which goes to Dr. Weinberg's area, and that is I am concerned about what I am informed is a very finite uranium resource in this country, and I wonder if the increasing dependence on nuclear power is not going to leave us, instead of being dependent on Arab oil, dependent, for example, on Russian uranium.

Why don't we start with the last question first. Dr. Weinberg, is Russia addressing that problem, the increasing number of light-water reactors and the decreasing amount of uranium in this country?

Dr. WEINBERG. I should point out it is precisely this issue that in 1942 had us all worried. This is better than 30 years ago, even before the first chain reactor started. We were fundamentally concerned with

whether nuclear energy was going to be a short flash in the pan, or really was going to be immensely important.

And it was exactly for this reason in those very early days, most of us felt the real measure of nuclear energy was the breeder. The breeder, I am sure—and I must take some issue with the ERDA documents—the breeder is, in fact, an inexhaustible energy source.

I don't mean by this a few centuries, but really inexhaustible. The essence of the breeder reactor is not that it makes more plutonium than it burns. That is not the central point. The essence of it is it enables one to burn large amounts of U-238 in the ground. People say that means burn 50 times as much as you now burn, but that again misses the point. The essential point is that it then makes available, as a fairly practical fuel, the low-grade ores, and there are many, many billions of tons of uranium in the low-grade ores, which are not acceptable energetically in a light-water reactor, but are acceptable in the breeder.

This is the essential reason why the breeder, despite all of the fusses you know better than I have been going on with respect to the breeder, it is precisely for this reason the breeder is the essence of nuclear energy in the long run.

With respect to the question you raised, is nuclear energy going to be a flash-in-the-pan, my answer is, yes; I think it will be a flash-in-the-pan unless we get on with the breeder.

I would turn the question around and say we could use this transition from the reactors that use this finite amount of uranium and use them in an inefficient way, that is, 30 to 50 years' worth of reactors, and use the transition from what I like to call phase 1 of nuclear energy to what I call phase 2 of nuclear energy, based on the breeder and which could last, despite all of the promises we hear, could last almost forever.

I think we should, at this time, open a clean piece of paper and say we are going to move into phase 2 of nuclear energy, or we probably will be moving into phase 2 of nuclear energy. What must we do to make that a fully acceptable source of nuclear energy? And I think that is one of the essential questions that faces us, the Congress must face, ERDA must face, all of the people of the United States must face.

It is on this account I dwelt at some length on what I think is the essential or one of the essential issues in that connection, which is the whole question of the citing policy for the long term.

Senator HASKELL. I wonder if I might interject.

Gentlemen, each one of you has your areas of energy. I wonder if these observations that each one of you generally or specifically articulated are endorsed by the group as a whole. You, sir, Dr. Weinberg, have long experience in the nuclear field. Really, it is not a question of setting up a budget; it is a question of how much you devote to what.

Each one of you has criticized portions of the budget. I wonder if those criticisms are shared generally by the panel, or you are articulating your individual interest, is what I am trying to get at.

Dr. KASH. I acted as chairman of the overview panel. One of the purposes of the overview panel was to arrive at an agreement, or alternatively to identify areas of specific disagreement that might have developed among the various fossil, nuclear, and so forth panels.

I think it is generally correct to say the written statements we presented here represent the views of panel members with slight nuances on the edges. I think there would be general agreement.

Now, Alvin has been very careful to express his own opinion with regard to these latter comments. Whether the panel would agree with regard to those or not, I do not know.

Dr. WEINBERG. I could say Tom Cochran on our panel certainly would not have agreed.

Senator HASKELL. What I am getting at, Dr. Weinberg, you feel very strongly more money should be spent, more effort made to develop the breeder. If we do that, maybe we are going to take some of this 2 percent on conservation away from Dr. Gibbons. We are dealing with very difficult things. That is why I am trying to find out whether these recommendations are individual recommendations or panel recommendations you are setting forth.

Do you follow me, Dr. Kash?

Dr. KASH. The written statements are panel recommendations. They represent a consensus of six panelists. Alvin's latter comments do not have that aspect. You have to draw that line, and at least from my point of view, if you start putting it in the very hard terms, you have to put it in, that is, if Alvin's comments are the future is breeder, and that is the highest priority, and you support other things after you have supported the breeder.

Then you can get argument along this table.

Dr. WEINBERG. I wonder if I should speak up and make clear that wasn't quite what I said. In asking for more money for the breeder, I was answering whether nuclear energy is a flash-in-the-pan. I was saying, yes; it is a flash-in-the-pan unless you go to the breeder.

Senator BUMPERS. I want to come back to my initial question. The really critical question is can ERDA quantify, can it set goals, and make itself accountable to the Congress on an annual or some periodic time basis so we can judge the results of the program they have laid down here.

Mr. DADDARIO. Mr. Chairman, in our summary of the comparative analysis, we do touch on that, and I would like to read a paragraph on page 2.

ERDA does not sufficiently convey the urgency required to address the near-term energy problems. The framework for a procedure to accomplish this objective exists within ERDA through its new 5-year forward planning system, which focuses on technology available in that period.

A set of annual milestones to meet near-term energy objectives, an annual reporting of progress in meeting those milestones would be very useful. They would give the Congress and the public the opportunity to evaluate progress and achievement of milestones, and that evaluation debate resulted in action to informing the American public of the energy problems facing this Nation in the decade ahead.

Executive and legislative report to achieve these program milestones would help to establish that sense of urgency and action.

That is the end of the quote, but it does point to the question you raise, and in a way through which progress could be reported and milestones reached or not reached.

Senator BUMPERS. Apparently the panel sees the same problem I do. Do you want to address that, Dr. Kash?

Dr. KASH. Yes. If I read your question correctly, it is asking is it possible for ERDA to set up milestones every year, it can come back

before this committee, and the committee can ask have you met that milestone.

If I may be partially facetious for a moment, ERDA can do that. Any bureaucracy can do that. What they can do is define, as next year's goals, what they have accomplished this year.

Then there is an old story that is what the Soviet Academy of Sciences does. It always justifies next year's budget in terms of this year's research results.

Now, if you ask a question more generally, I think there is an over-emphasis on trying to quantify results which you measure on a year-by-year basis.

Point No. 1. Most of the ERDA budget is being spent on technology, hardware, which, if it is in terms of your original statement about what we want is energy, what we want is results, then it is not going to have any payoff for 5, 10, or 15 years as time dimensions alone.

One kind of criticism you can aim at ERDA and you can aim at it without much difficulty is that its time horizons tend to be mid-term, beyond 1985 timewise. Most of this is focused on a payoff that will not be here for 10 years. You are talking about commercially producing energy.

One point the panel identified, and it seems to me the committee and the Congress has its feet stuck in whether it likes it or not, is the potential for short-term payoff from hardware, is tied up with getting commercial demonstration plants built, high Btu gasification, oil shale, precombustion cleanup plants. If you want to put a few billion dollars into those, build them and test them over 5 or 6 years, you may within the next decade be able to get some commercial production.

The other area where you can get some short-term payoff, it seems to me, is in what the OTA document earlier called nonhardware research. There is a lot of resistance to energy development, in my judgment, that is associated with uncertainty about what it means.

If you want to get a million barrels of oil shale, oil using 50,000 barrel-a-day plants, each of those requires a mine larger than any mine in operation in the United States. If you use extreme projections, half of the water in the Colorado River—what you can do when you look at these data, you can find tremendous variations in estimates of how much water is available, how much would be used, and there is a great need for getting some reliable information.

But if you want real payoff on a short-term basis, this budget has got to jump dramatically. That is not the panel's view; that is Don Kash's view.

If you are asking to take the program ERDA has now and have them demonstrate in some quantitative terms next year and the year after what they have produced, then you are forcing them to play.

What I would do, if I were administrator of the agency, I would define a set of goals which I could then come in and prove that I had achieved. I think if you try to get very hardnosed in terms of quantitative measure, what you are going to do is create a monster worse than what you have got.

Senator HASKELL. Dr. Kash, perhaps this is a question you might have examined. As you know, taking the demonstration area is a concept built into the legislation of a private governmental park.

I have been told this has not been working very well because of the difficulties of negotiating any joint venture, and the United States would be far better off if we just hired the job done. That is what I have been told. The heck with this joint venture stuff. Just hire the job done.

I would like some comments, and I am not saying this is my view, but I am saying this is what has been told to me, and I would like some comment.

Dr. KASH. I have already used my fair share of the time here. I will try to make my comment brief.

I don't think that will work unless the whole philosophical background that we bring to bear in this society changes. The legislation establishing ERDA, statements by the executive branch, by ERDA itself, all share one point, and that is energy in this country is going to be produced in the private sector.

Senator HASKELL. Don't get me wrong. I am not saying it should not be produced. These people, who have been telling me this, are the private sector. They say they prefer to be hired, I guess the way you hired folks in the days of early atomic energy.

Dr. KASH. That is not a pitch I hear very frequently. I see a real dilemma with ERDA as to how you carry out a program with the Congressional Budget Offices. It may be \$64 billion over the next 10 years, which has the Government paying for R. & D. which is to be transferred into the private sector.

You develop the technology. You put it in the private sector. And you allow the private sector to make a profit on it. How do you deal with these ideological issues where liberals are suspicious? Industry is ripping off the public money, and conservatives are worried. If you get in bad with the Government, essentially nationalization takes place without ever formally being legislated.

I don't think there is any answer without cooperation.

Senator HASKELL. You think it is working the way it is?

Dr. KASH. I don't think it is working very well the way it is, but I think cooperation is absolutely necessary. That again is a personal view.

Dr. GIBBONS. I might add a couple of comments. I believe the American people and the Congress deserve progress reports on where their investment is going and how it is paying off.

I believe, however, the progress report for ERDA should be tooled to ERDA's plans, and ERDA's plan is not easily measurable in terms of how many new barrels of oil we have found this year.

There are ways of reporting progress. The ERDA-76-1 begins that strain, and the energy outlook of FEA could be better integrated across the Federal agencies to give the Federal agencies better energy reports to Congress.

But it seems to me there is another kind of information that could be helpful if provided to the Congress. That is a more explicit discussion of the basis of priorities, the criteria of choice of the agency, and how it proposes to spend its money, these criteria and priorities based on ERDA's explicit discussion of what it anticipates the payoff to be and how that payoff compares to other investments it could be making.

I think this is probably already operational within ERDA. It might be better to have it more explicit.

Dr. PENNER. I would like to make a brief comment on this question of large-scale commercialization over the near-term which Dr. Kash addressed.

I would like to preface the remark by saying this is not part of the OTA panel activities, but the statement I make is the result of a panel study of which I was chairman for NSF Rand in which we addressed specifically the issue of commercialization of in situ recovery of shale, partially mining, partially underground recovery.

The report was published in August of last year as a GPO publication. If you look at the action item conclusions to which we came in the study, I can summarize them by saying it seemed to us one could not really effect commercialization without a very much larger program than currently contemplated by ERDA.

You might argue you could do this on, say, 10 percent of a commercial scale level or 1 percent of a commercial scale level. Yet when we looked at this problem with some care, it seemed to us the proper assessment of the environmental constraints, the water constraints, the air pollution constraints really could not be made on a small scale, and that was an area where a large-scale government-industry cooperative program would be needed over the very near-term in order to establish technical feasibility, environmental acceptability, and economic costing at a believable level.

I say this even though our panel study suggests the cost estimates were, in fact, competitive at current international oil prices. I really should refer to this report for full elucidation.

Senator HASKELL. What was the name of that report?

Dr. PENNER. The NSF Rand Workshop, UCSD—standing for the University of California at San Diego—on “The In Situ Recovery of Shale Oil.” The date is August 1975. It is a GPO document, about 400 pages long.

Senator HASKELL. I will get that. My State is Colorado so I am very interested in that.

Senator BUMPERS. Let me pursue that. Is it not practical for the Congress to say to ERDA:

You know how much energy the country is going to need and you know essentially what forms we are using right now. Can you project out to the year 1990 to 2000, diminishing domestic supplies of natural gas and oil against those increased demands which are certainly going to exist in those years?

And then ask them to say here are the options this country has for filling those deficiencies or meeting those deficiencies. ERDA might, for example, say one of the most viable possibilities is high-Btu gasification, but we need a demonstration project that is going to cost \$2 billion, and we need to evaluate it for 5 years. They could come to Congress and say, “We need \$2 billion to build a demonstration project which has great possibilities,” and here are the cost and benefit.

Another possibility is wind energy. We have a demonstration program going on in Sandusky, Ohio right now. If it looks like it is feasible, why couldn't ERDA tell us what percent of our energy needs can be met with wind energy.

Why not? I still don't understand why ERDA could not come to us with some of those kinds of options, with some cost effective figures, so we know about what we are headed for in 1985 and 1995.

It occurs to me we are broadcasting money right now and hoping something will grow.

Dr. WEINBERG. I guess I would like to spring in some degree to the defense of ERDA, Mr. Chairman. I would quote, for example, from ERDA-76-1, volume II, in which they speak about what they think can be done with high-Btu, gasification, and the claim made here, and I quote directly from the document, is—well, they speak of what their objectives are, and then they say:

The support of these activities may be capable of providing an energy production gain of 6.8 quad by the year 2000, available in substitutes for natural gas.

I think ERDA, throughout this document, has tried to make estimates of what one hopes to get in the way of additional supply, and, indeed, in reduction in demand through conservation.

I suppose one could argue how reliable are estimates of this sort, and I think those who make these estimates are the first to agree these estimates are not all that very reliable. But I do think the Office of Planning and Analysis in ERDA, which has been responsible for putting much of this together, has made an attempt insofar as they can to estimate what contributions to the energy supply will be achieved by the year 2000 if these programs are successful.

Senator BUMPERS. One of the handicaps Congress labors under, and particularly in this energy field, and this is the reason you are here this morning, this is the reason OTA is so important to Congress, and that is that ERDA has to submit to us pretty much what OMB tells them to.

They have to be responsible to the administration, the executive branch, and quite frankly, with no depreciation of the executives over there or the agency, they come here essentially under the restraints OMB has put them under, and we have to allow people such as you and OTA to try to give us an honest, objective analysis so we can then go to ERDA and say:

Despite OMB's best efforts, we are willing to go with you if you will just tell us, is OTA correct on this if we put more money into high Btu. gasification, can we expect results.

And then we know how to deal with it.

But as Senators representing not only our States but the whole national spectrum, as far as energy problems are concerned, we are laboring under severe handicaps because of policy matters.

It occurs to me the whole gamut of goals the country could set for itself, the one thing that is flexible is conservation. Conservation will have to fill whatever deficiencies the country has of its energy resources. I have maintained all along the country could live with considerably less energy without affecting economic conditions in the country or our lifestyle, for that matter, but there is going to have to be a visible conservation effort.

Right now ERDA has no such program on the drawing boards nor does Congress. So what is happening is people continue to buy bigger automobiles, they continue to drive them, they continue to use energy at a high rate.

I have contended all along ERDA has not come to us with what I consider a very dramatic, viable program, and the amount of budget being allocated to conservation reflects that.

Dr. GIBBONS. I share your conviction with a good deal of backup information that there are a vast number of options available to us, particularly given the higher price of energy, to do something other than just buy more energy. In large measure, this means essentially no sacrifice of lifestyle or standard of living.

It simply means spending that money where we can achieve minimum cost, for example, building more efficient air-conditioners. There is a refrigerator on the market today that uses 40 percent less energy, and sells for only 3 percent more than its competitors.

Senator BUMPERS. Tell us what brand it is. Let's give somebody a plug.

Dr. GIBBONS. It happens to be Philco and it is advertised in most magazines these days as a new marketing strategy.

I think there are things we can do other than pay the utility companies more money, and the company will respond. I think it is incumbent on the Federal program to play a leadership role in making sure the American public gets good information. Given that good information, hopefully it will make a wise decision.

There are also substitutes for energy. The idea of reinsulating America's buildings not only provides a lot of productive jobs, but uses our dollars in hiring people to go to the attic and putting in insulation.

So there are many things we can do productively in the face of the new energy crisis, and it is time we got started on this. The longer we wait, the more money we waste.

Second, the tougher the problem gets as we move toward the end of the century, I think there is an urgency to begin now to do those things which will have their payoff in the latter decades of the century and as we move into the next century.

It has been variously estimated, but it is felt at present prices and particularly with present price trends we can increase the efficiency with which we use energy in the United States in a productive way by at least 40 percent. That will take a long time. It will take decades. But it is time to begin now.

One of the problems we have is that energy conservation can work so well in the near term. We lose sight that it also has very important long-term benefits. That is one of the criticisms of the ERDA plan, that it focuses on the near term where there are surely many options to take advantage of.

But one must not lose sight of the fact there are many exciting potentials for increasing the efficiency of energy use if we simply make that long-term R. & D. investment.

If I might finish by going back to your point about long-range planning and attempts to better project the way we could move more gracefully into the end of the century. There are a couple of studies ongoing now that should help illuminate that condition within the next 12 months.

ERDA is sponsoring, through the National Academy of Sciences, a study of alternative energy futures through the end of the century and on into the year 2010. This is called the Committee on Nuclear and Alternative Energy Systems, chaired by Professor Brooks of Harvard and Dr. Edward Ginston.

The results of that will not be available until late spring or approximately a year from this date. It should be a helpful document. There will be a study of a workshop in about 3 weeks in which the FEA's large energy model will be critiqued and reviewed by a number of observers from all over the country. This will help hone that difficult process of looking far down the road.

Dr. SEIDEL. I would like to pick up on both of your questions. On the question of planning, your comments are really speaking to the point of one of the criticisms that was made by OTA of ERDA-48; that ERDA viewed its mission, at least at its inception, as being not a problem-solver, solving the Nation's energy problems, but as an agency to develop hardware that could be put on a shelf, and then those that wanted to use it, and industry that wanted to develop from that starting point, could go on and use it. So it was not to solve the energy problem directly itself, but rather to provide the technology that then someone else could use.

I think we have seen in going from ERDA-48 to ERDA-76, a solution in taking a harder look at strategies and where they would be asked to put their money. I think you will see the kind of planning you recommend.

With regard to conservation, I think everybody agrees this is probably the most cost effective way of achieving energy independence and solving our energy problems. I think what has to be addressed is the reason for the Federal involvement in energy conservation.

I believe much of the administration believes it is the role of the private sector that there is a real significant difference between the supply and demand side, and when you start to fool around with conservation, you are playing games with consumer preferences lifestyles.

It is this question that has to be addressed when you talk about Federal involvement. My own personal belief is there is tremendous room and you are not doing enough in conservation, but that is an issue that has to be talked to.

Dr. GREY. I would like to make one point which I believe has been highlighted. Conservation cannot be considered by itself. Conservation is implicit in all of the other energy technologies we deal with.

In solar energy, for example, one of the principal gains in going to a solar-heated system is implied in the use of proper insulation in the house or whatever device is being utilized. We have talked about total energy systems which is a form of conservation. This is implicit in the design of the fossil or whatever the primary source of energy is going to be.

In waste it is necessary to apply a bunch of different technologies in addition to the classic technologies. I think this is reflected in the fact this is not really an ERDA problem. It must be dealt with by the Government and by private industry across the board.

The FEA, for example, could effect much greater measures of conservation in the next 5 years than ERDA. In considering conservation, you people in Congress, particularly, must consider the many different agencies and technologies in producing an effective conservation program. It is not just the ERDA conservation budget that is giving us conservation; it is a much broader conservation.

Dr. WEINBERG. I would like to carry on a bit in this vein, and point out some of the basic problems ERDA has, and all our policymakers

have. It is precisely the matter of trying to figure out what the energy demand is going to be in the year 2000, and work backwards and see what should we do in order to meet a projected demand in the year 2000.

If you examine the programs, they visualize the future in which energy went up very rapidly. In the intervening years, we have become more sophisticated about what we think our energy demands are going to be. I guess I am not quite convinced that this higher degree of sophistication, which generally leads to lower demands in the future, has, indeed, been fully reflected in all of the programs that ERDA is presenting before the Congress.

In connection with what Jack Gibbons said a few moments ago, my own Institute of Energy Analysis is pretty well convinced that instead of the demand in the year 2000 being like 150 quads, which is a number that many people as recently as a year or so ago were taking quite seriously, we think it might possibly be as low 100 quads, and this does not involve a great change in lifestyle but as much as anything depends upon the fact most of the people who are going to be living in the year 2000 are already born. So the population in the year 2000, instead of being 340 million, which was the old projection—in 1960 at that time, it was assumed the population would be 340 million—it looks much more like it is going to be 240, 250 million, and that makes a tremendous difference.

I am no better a soothsayer than anybody else, and in some ways much worse, but I do have the merits of being I suppose rather older than anybody else at this panel, and, therefore, I can't be fully responsible for what is going to happen in the year 2000.

I point out I think this underlying perception of what the demand is going to be a long time in the future must affect the perception of what the proper research and development programs are going to be, and I would hope as things go on, ERDA will take this more and more into account.

Dr. KASH. I would make two quick comments. One, I want to underline Alvin's comments. We were over to visit his center sometime back, and we were involved in a study, and part of the discussion was how do you design an energy R. & D. supply budget if you don't make any assumptions about energy growth. If you do not have any demand levels, what would you do? Forget about that. That is one of the things we have been trying to do.

The demand projections appear to be very uncertain and for the reasons Alvin has suggested, as well as others.

I would make one comment about conservation. It is very hard to look at the ERDA budget and not be convinced that more needs to be done. I have not been impressed with the substantive proposals for additional R. & D. on conservation. That is, there is not, in terms of what I see, a great catalog of substantive proposals of new things to do.

I was intrigued by John's comments. I think the proposals you made appeared in that old Office of Emergency Preparedness study done 15 years ago.

Dr. GIBBONS. Those were examples, not proposals.

Dr. KASH. I understand. There are simply differences in the amount of money these areas can absorb at the present time. I have not seen proposals for conservation that deserve vast increases. I think clearly more needs to be done if for no other reason than symbolic inferences.

Dr. PENNER. It is difficult to pass up an opportunity to comment on the problem dearest to our hearts, conservation of energy. I don't think we have developed yet in this country, a conservation ethic to eliminate waste, and it is not at all clear that this is part of the energy program, but it clearly ought to be a part of the Government's program, and it doesn't matter too much where it is set, but we really do not conserve when it costs us essentially nothing.

I think the ERDA emphasis on improved new technology for conservation is a properly placed emphasis. It is very much easier to do things right the first time than to retrofit.

I would like to give an example on retrofit. Some years ago we made a study on how much energy was wasted where I live in California where we have wonderful climate, as you all know, and use minimal amounts of energy for heating, where we were wasting about 30 percent or so in running our gas pilot lights because our duty cycle is very short. The pilot light is on all the time. Yet we heat only very, very rarely during the day.

These continuous pilot lights are legislated by, in this case, State ordinances because it is not safe to turn the thing on and off the way we used to do in the old days. The question came up, why don't we replace them in existing homes. It turns out you can build a gadget that will do this job for something like \$12 using the existing parts. You can probably do it more cheaply on a mass production scale.

Here we have this wonderful idea of saving 30 percent of the energy in the home heating sector by putting in a \$10 or \$12 gadget, but to put in the \$10 or \$12 gadget: (a), required a change in law because this would have been intermittent lighting; (b), would require a plumbing union; (c), an electrical union; and (d), required a building contractor.

By the time you figured out what it cost to put this low-cost item in to save this energy, the cost was so high it really looked like a very marginal proposition. In fact, the small company with whom we communicated on this issue, after making a marketing study, said there was no value in proceeding with this idea. There was no point in proceeding with this idea.

Senator BUMPERS. That is an excellent example, Dr. Penner. Last year I was Governor. We were facing some of these problems. I was told that homes that used gas for heating used more gas for pilot lights than they did for cooking.

Have you ever heard that? Is that true?

Dr. PENNER. I believe that is very much true, yes.

Senator BUMPERS. Would the same thing be true of pilot lights on hot water heaters? There you have some utilization of the pilot light.

Dr. PENNER. I don't have the numbers at hand. The other number is a reasonably firm number. Measurements were made. So this would be 30 percent of 11 percent of our energy use in our region.

Senator BUMPERS. In marking up the Energy Conservation Policy Act of 1975, the appliance manufacturers in this country did not like it very much, but they said they can meet the goal of 20 percent energy savings within 5 years in appliances.

Dr. Gibbons, you say Philco has a refrigerator which will operate at something like 40-percent less energy use?

Dr. GIBBONS. That is correct.

Senator BUMPERS. The one with the icemaker, the automatic defrost, that sort of thing?

Dr. GIBBONS. Yes.

Senator BUMPERS. I wanted to go back to a statement Dr. Seidel made, that might need legislative correction, but you talk about how ERDA perceived its role. It perceived it, really, as an agency that would develop hardware, for example, or assist in the development of hardware that would go on the shelf, and industry could use it if it chose to.

You say in the new plan, they perceive themselves in a slightly different role. Have I interpreted what you have said, basically?

Dr. SEIDEL. Yes.

Senator BUMPERS. That is very interesting to me. I would personally define ways which we could develop technology and put on the shelf, and bring it out when we needed it. I would like to buy Arab oil as long as it is available to us, as long as we can afford to.

I wish there were some optimum or middle area where we could become energy self-sufficient but not have to use our resources to do it, and continue to buy Arab oil.

Dr. KASH. Senator, I would like to make a proposal, if I might, and it is that we buy all of the Arab oil that we can buy, simply maximize it over the next 25 years with an agreement with the Arab nations that at least half of what they pay or what we pay for the oil has to be reinvested in American companies. So that presumably at the end of 25 years, Arabs ought to own 70 to 80 percent of American industry at which point we nationalize them.

Senator BUMPERS. I visited with the Shah of Iran a couple of weeks ago and I tried that on him, and he didn't go for it. [Laughter.]

You mentioned improved technology in oil spills. Could you describe for me the state of the art in cleaning up oil spills right now?

Dr. SEIDEL. That is not my area, sir. I was involved in the fossil panel, but with regard to oil spills, I think Dr. Penner might be able to speak to that better than I.

Dr. PENNER. I would like to pass. I know a little bit about this, but I am not expert.

Mr. DADDARIO. Mr. Chairman, we are presently analyzing an assessment in this area. We believe we will be getting a study together on it quite soon.

Senator BUMPERS. I understand the state of the art is very advanced. I want to know about it. In the offshore drilling bill, which we considered last fall, we put a substantial amount of money in a trust fund. All the oil that is drilled, a percentage of the revenues will go into trust funds of the States to be used for that purpose.

There was quite a brouhaha about how much money needed to go into the trust fund. I think it could go up to as high as half a billion dollars. We had some discussion as to how effective cleanups are.

Mr. DADDARIO. Mr. Johns can make some comment on that program. He has worked in our oceans program.

Mr. JOHNS. The oil problem, as far as recurrence of oil spills in offshore waters, a harbor-type thing, or prevention of the spill, and the same thing occurs offshore, as far as preventing the spill or cleaning up—on the inshore areas, there are several systems quite successful in fencing off the oil and allowing absorbent materials or sweeping

material, a fencing and scooping separation, to successfully recover a very large percentage of the oil.

In the offshore areas, there have been developments by the Coast Guard and private industry to fence and recover oil as well to sweep and scoop it off the surface of the water and recover it.

The problems occur when you have a very active sea, the devices which are sweeping it, some of the materials are much less effective. Further, the time frames you have involved are much shorter because the oil in the oil water interface, interact and emulsify, and form more difficult materials to recover; in addition putting up a fence against the physics of an active sea is difficult.

So the state of the art has improved considerably over the past 5 to 10 years, but there are still limitations principally with regard to sea state. The concentration has been, therefore, more in the area of trying to prevent oil spills and improve the handling and methodology, and, again, there has been significant industry contribution and effort in that area because they are carrying the liability. They are obviously trying to reduce the risk.

Senator BUMPERS. Do you know how much ERDA is devoting to improving technology in this field?

Mr. JOHNS. I don't know what the ERDA dollars are. We cannot identify them in the subprogram area, but there are other dollars from EPA and from the Coast Guard that are being expended there.

Dr. KASH. The ERDA dollars are almost nonexistent with regard to cleanup. If you are very generous, you are now talking about \$1 million, but that may not be particularly serious. The primary responsibility for mechanical cleanup devices such as Skip has just talked about are in the hands of the Coast Guard.

The Coast Guard is spending around \$25 million a year if I am not mistaken, and responsibility for nonmechanical, that is for detergents and chemicals to treat oil spills, is the responsibility of the Environmental Protection Agency.

My recollection is that the expenditure is in the range of \$10 million or so.

I would add one point to Skip's comment. Mechanical devices, things that absorb the oil or scoop it up, work only up to waves of 6 or 7 feet, a very significant limit. You can use detergents, other ways of treating the oil in heavier seas.

Unless things have changed significantly in the last couple of years, almost all of the North Sea countries, for instance, were using chemical treatment techniques. That is kind of interesting because part of the rejection of chemical treatment in this country is frequently explained as being associated with the *Torrey Canyon* accident when detergents were used to treat oil on English beaches, and it turned out on investigation that the detergents were more damaging to the birds than the oil was.

What the British did was to develop a much less toxic set of chemicals. There are some people who are arguing we probably put too much emphasis on mechanical cleanup devices and too little emphasis on chemical and other types of devices.

There are physical limits to how far you can go with mechanical cleanup which has been the preference in this country.

Dr. GIBBONS. I served on a panel reviewing the EPA's—one reaction, they were spending an overamount of attention—and perhaps the conclusion of that panel was we ought to look at program balance between offshore and things happening on the continental United States.

Senator BUMPERS. I have one other question—Dr. Penner talked about this—that is, oil shale; was that the area you covered?

Dr. PENNER. Three of us.

Senator BUMPERS. What I wanted to ask you was what, if anything, do you know about Occidental's operation in Colorado? How successful has it been?

Dr. PENNER. The Occidental group participated extensively at the NSF Rand UCSD workshop.

Senator BUMPERS. Have any of you visited the site of the Occidental project?

Dr. PENNER. Yes; I have. I would like to emphasize, to the best of our ability to judge this, the total number of dollars spent by Occidental on this mixed mining and in situ recovery is relatively small. I would think as of the end of last year that budget was well below \$10 million. They have done very well with that program, and they are very optimistic about the final cost of the product that can be produced by this technique.

The statement that comes to my mind by the Occidental representatives repeatedly is that if they had a guaranteed market at current world prices, they would not hesitate, but to go to larger development on their own. The problem is, considering the intrinsic cost of oil in the Middle East, there can be no guarantee oil will stay above \$10 or \$11 a barrel. Then this technology becomes marginal.

In our workshop conclusion, we considered this to be a critical issue for the Government to address, to provide a guaranteed market, at least for some years at some level, for oil produced in this way at this high price.

Senator BUMPERS. To be brutally frank, I have heard it said if they could get Government leases, they would go into business on a grand scale right now. It is a very happy thought, particularly if they can do it with in situ process which is the least damaging environmentally, but I have great reservations about that.

I have been intending to go out and look at that site. I would think if Occidental or anybody else—I don't think Exxon, Texaco, would hesitate a moment to go into that business if they thought they could produce that oil at \$8 a barrel which is, as I understand, what Occidental is professing to be able to produce it for.

Dr. PENNER. They are being more optimistic than that, I am afraid.

Dr. GIBBONS. It might be interesting to ask Occidental if they would be willing to sign a long-term contract to deliver at that price.

Dr. PENNER. I think Mobil would be willing to deliver at a price around \$11 or \$11.50 per barrel at the current international price. I don't think anyone will do it at \$8 a barrel.

Senator BUMPERS. Occidental is aware of a universal opinion that oil will never be any cheaper than it is right now. Therefore, I have a difficult time accepting some of their data.

Gentlemen, do any of you have any further comments?

I just want to say how much I appreciate your being here. It has been very stimulating for me. We may submit, with your permission, a few additional questions in the areas you have testified on. My best questions always come in the middle of the night, not in the morning.

We appreciate the work you have done. We are deeply gratified. I apologize that not more members of the committee were here.

[Whereupon, at 11:55 a.m., the hearing was recessed, to reconvene at 10 a.m. Thursday, July 29.]

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ERDA LONG-RANGE PLAN AND PROGRAM

THURSDAY, JULY 29, 1976

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND WATER RESOURCES,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 3110, Dirksen Office Building, Hon. Dale Bumpers presiding.

Present: Senators Bumpers, Stone, Fannin, and Hansen.

Also present: Ben Yamagata, counsel; and Christopher Coccio, science consultant to the committee.

OPENING STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator BUMPERS. The subcommittee will come to order.

Today we are continuing the Interior Committee's oversight hearings on the ERDA long-range plan for energy research development and demonstration. On the first day we heard Dr. Seamans, the Director of ERDA, present the plan.

Yesterday, we had an extremely distinguished panel consisting of the Honorable Emilio Daddario, Director of the Office of Technology Assessment, and the chairmen of the various OTA task force groups dealing with the ERDA plan. These gentlemen raised a number of crucial issues concerning the plan and, more broadly, our energy future. Particularly, they praised ERDA's new-found interest in the role that energy conservation and efficient energy use can play in coping with our energy problems, but pointed out the gap between this position in the plan and ERDA's actual programs. Only 3.8 percent of the ERDA energy budget was allocated to energy conservation, and only about half of this was really conservation in the conventional sense. The over-emphasis on electric energy R. & D., to which I referred on the first day, was underscored by members of the panel.

Problems in the basic research program, overly optimistic estimates for the potential for synthetic fuels, the proper role of the breeder and other nuclear technologies, and inadequate attention to environmental and safety programs were also cited. Finally, we had an excellent discussion with the panel on the best means by which ERDA can make cost effective decisions and Congress can monitor the progress of the ERDA program.

Today we examine additional dimensions of the ERDA plan. We will begin with a look at the potential contributions of some conservation technologies and the environmental implications of the ERDA program, using the analysis prepared by the President's Council on

Environmental Quality. This testimony will be followed by Dr. Barry Commoner who will, in his usual stimulating fashion, provide us with an assessment of the consequences to our Nation if the plan is followed.

Finally, we will hear about the budgetary implications of the ERDA plan from Dr. Richard Dowd of the Congressional Budget Office.

I am pleased to welcome you gentlemen to the hearings, and to thank you in advance for helping this committee and Congress in the important task of overseeing and shaping our short and long-range energy future. We will now hear from our first witness this morning, Mr. Steven D. Jellinek, Staff Director of the Council on Environmental Quality.

Mr. Jellinek.

STATEMENT OF STEVEN D. JELLINEK, STAFF DIRECTOR, COUNCIL ON ENVIRONMENTAL QUALITY; ACCOMPANIED BY CHARLES P. EDDY, SENIOR STAFF MEMBER FOR ENERGY PROGRAMS

Mr. JELLINEK. I am accompanied this morning by Charles P. Eddy, the senior staff member for energy programs.

On behalf of the Council on Environmental Quality, I am pleased to have the opportunity to present to this subcommittee the Council's views on environment and conservation in the Federal energy R.D. & D. programs. The Nation's health and welfare, over the long term, will depend in large measure on how well we are able to deal with the energy realities of the next 25 years. And the success or failure of energy research, development and demonstration, both public and private, will play a crucial role in our energy future.

We believe that role can be successful if we develop new sources of supply that meet rigorous tests of environmental acceptability, and if we make significant improvements in our ability to produce and use energy efficiently. In both respects, the Nonnuclear Energy Research and Development Act of 1974 gave the Council on Environmental Quality new and unique oversight responsibilities. As part of these new responsibilities, this fall CEQ will transmit to the President and the Congress our first report assessing the adequacy of Federal non-nuclear energy R.D. & D. programs relating to energy conservation and the environment.

Today, I would like to examine briefly certain key aspects of these programs.

Our assessment and this testimony focuses on the Energy Research and Development Administration and, to a lesser extent, on the Environmental Protection Agency. We have studied ERDA's program planning and implementation from the time the National Plan for Energy Research, Development and Demonstration was published in 1975 through publication of the first revision in April 1976.

At the outset, I wish to emphasize the context of our first assessment effort. This has been a tough period of organization start-up and program development for ERDA. Indeed, we are concerned that its difficulty may not be widely recognized, leading to expectations that are impossible to meet. The agency's top managers and their staffs have made diligent efforts to develop research programs that respond to the Nation's needs. We believe that ERDA has made much progress to date, is aware of the shortcomings in its present efforts, and is taking

steps to remedy the problems. Nevertheless, after 1½ years, there remain important areas where we believe accelerated and expanded improvements in program planning and implementation are necessary.

Turning first to energy conservation R.D. & D., the Council has two major concerns: While ERDA has analyzed the potential contributions of some conservation technologies extending beyond the near term, it has not yet implemented a process to comprehensively identify detailed conservation options for the mid- and long-term and select those opportunities appropriate for the Federal research program; and ERDA does not yet base its resource allocation decisions on comparisons of the costs and benefits of all R.D. & D. opportunities, including conservation.

In its revised national plan, ERDA singled out near-term conservation technologies for increased attention and ranked them with several supply technologies as being of the highest priority for national action. This represents a major change from the initial plan and reflects ERDA's "observations of only moderate progress to date on supply technologies, evaluation of public comment on the initial plan, and further analysis of conservation opportunities."

The Council agrees that, in the near term, national attention should be devoted to implementing currently feasible energy efficiency improvements. In this time period, important improvements in the efficiency utilization of commercially available technology as well as through the development of new technology.

But R.D. & D. is but one means of achieving energy conservation, particularly in the near term. For example, a number of other Federal agencies have significant conservation programs. And the Council recognizes that the private sector has the principal responsibility for achieving the Nation's energy goals; the Federal R.D. & D. role should concentrate on that which cannot be done privately.

Yet it is precisely the more advanced, longer term conservation R.D. & D. options, which have substantial technical and economic uncertainties, that are most likely to be neglected by the private sector. In such instances the contribution of Federal R.D. & D. programs could be critical. Among the conservation R.D. & D. opportunities for the Nation that may pay off over the mid and long term are second and third generation heat pumps and fuel cells, advanced automotive engine systems, and better building materials. Yet, with the exception of transportation, ERDA has not developed detailed plans for end use conservation for the period after the mid-1970's.

All R.D. & D. options must receive full consideration while ERDA is in its formative stage. Momentum tends to build as commitments are made to particular technologies and continues as multiyear claims are made on future funds.

Already, there is great momentum behind a number of mid- and long-term R.D. & D. programs. Inadequate attention to energy conservation in the formative stages of this new agency poses the risk that well-established supply technologies will capture the major funding priorities and, because of a combination of sunk costs and inertia, leave precious little for advanced conservation technologies that could be far more cost effective.

This leads directly into our second major point on energy conservation: All energy R.D. & D. options must be compared on an equal

footing. Sound planning requires that ERDA base its choices for R.D. & D. funding on the fullest possible comparison of the costs and benefits of competing programs, regardless of whether they are supply or conservation programs. Not only dollar costs, but also environmental costs and benefits must be explicitly considered. ERDA has made such comparisons in establishing broad agency priorities, but it has not yet done so for allocating scarce funds among competing technologies. This may be reflected in the ERDA budget. In the proposed fiscal year 1977 budget, end use conservation R.D. & D. received an increase which is twice the overall agency average. However, in absolute terms, end use conservation is one of the smallest of the energy R.D. & D. programs.

At this time there appear to be good reasons for the present low level of funding. Conservation, though growing fast and absorbing funding at a rapid pace, is a new program. It is in the planning and development state, whereas many older supply programs are already into the more expensive demonstration stages. In the near term, furthermore, it may require less government involvement. These constraints may be ameliorated with time.

Turning to our evaluation of the environmental programs associated with energy R.D. & D., we have, once again, two major concerns. First, ERDA's environmental research program thus far is not based on an adequate system for identifying and ranking environmental problems.

Second, environmental research and technology development are not scheduled in phase with each other, with the possible consequence that new energy supply technologies, as they develop, may not be acceptable from an environmental standpoint. ERDA is taking a number of steps to improve its environmental programs. For example, ERDA's Office of Environment and Safety, which has primary responsibility for developing an adequate environmental program, recognizes the need for an effective, systematic approach, and is starting to redirect environmental research through its balanced program plan.

In our first assessment we concentrated on the environmental research programs that are ranked highest in priority by ERDA, that is, coal conversion technologies, particularly those that produce synthetic liquid and gaseous fuels.

CEQ independently examined the information available on the types and amounts of pollutants associated with synthetic fuel technologies, together with data on their health and ecological effects. We found serious information gaps in both subjects. This is a matter of great importance because, despite the gaps in scientific knowledge, we do know enough to expect that many potentially hazardous substances will be present in both the useful products and waste streams of advanced coal conversion technologies.

So far, ERDA's environmental research planning for coal conversion technologies has been mostly ad hoc. Central guidance aimed at solving the known problems of these technologies or identifying potential problems has been lacking. The balanced program plan is designed to correct this.

Two problems appear to remain, however. First, while the initial draft of the balanced program plan will be used in formulating the fiscal year 1978 budget, the link between the plan and the budget will not be completed until fiscal year 1979 and beyond. This could impede

commercialization of near to midterm technologies. Second, the coal technology program has had limited direct involvement in developing the balanced program plan. Without close, direct involvement between technology development and environmental research there is no assurance that the research will address the needs of the specific developing technologies.

If the research is coordinated with each stage of the technology development process, then environmental information will be available in time to influence technical and engineering decisions on succeeding stages. Technology development schedules should be drawn up to correspond with the availability of environmental information. Environmental research must begin early in the process and keep pace with hardware development.

ERDA's current projections for coal conversion technologies suggest that several large demonstration plants may begin operation in 1980 and 1981, with possible commercialization in the mid-1980's. Our review concludes that associated environmental research is not yet in place with the technology development schedule. For example, there has been only partial identification and characterization of pollutants at pilot plants. The Council believes that ERDA should continually reevaluate its schedules for the demonstration of all non-nuclear technologies—near-term, mid-term, and long-term—to assure adequate environmental information will be available for informed decisions on commercialization, environmental standards, and control technologies.

We strongly recommend better coordination between ERDA and the Environmental Protection Agency in setting environmental standards for coal conversion facilities. A close working relationship between these agencies is essential.

All stages of technology development—laboratory, pilot plant, and demonstration plant—should be designed as working environmental laboratories as well as technical test facilities. They should be planned to produce the new environmental data needed for developing regulatory standards and controls for new technologies. EPA, for its part, must be prepared to provide guidance to ERDA on designing facilities both to meet existing standards and to provide information on potential new pollutants.

Finally, CEQ is also concerned that a number of decisions related to nonnuclear R.D. & D. are being made in the absence of programmatic environmental evaluation. With the exception of the proposed synthetic fuels commercialization program, no nonnuclear environmental impact statements have been prepared by ERDA and filed with the Council. However, a draft statement is being prepared for the fossil energy research program, and assessments are underway on other programs. ERDA is still operating under impact statement guidelines prepared for the Atomic Energy Commission, and has not yet revised its procedures to take account of the research problems of its diverse nonnuclear programs.

In closing, I want to emphasize that CEQ recognizes improvements in ERDA's environmental and conservation programs over the past year. Yet we believe that the problems we have identified merit high-priority action to assure sufficient attention to conservation and adequate protection of the environment.

This completes my prepared testimony. I will be happy to respond to any questions that you may have.

Senator BUMPERS. Thank you very much, Mr. Jellinek.

In your first couple of pages of your testimony, you point out that ERDA has made substantial improvements, that the problems they are trying to cope with have not been widely appreciated or recognized. I could not agree with you more. I hope we are not here today as adversaries, but as constructive critics.

I think in the byzantine atmosphere of Washington, everybody figures you are for us or against us. Any time anything is questioned, it is assumed you are an adversary.

What we are trying to establish here is some plausible and feasible method of assisting ERDA, not only in critiquing its plan, but trying to relate the budget process to that plan. It is most unfortunate, here we are—after \$6½ billion has already been authorized and appropriated to ERDA—here we are a few months after critiquing a plan when this should have been done long before the budget was brought to this committee.

The cost effectiveness of various approaches is one of the things that Congress does indeed to know, and to exercise its oversight responsibility on.

I appreciate your testimony very much and I believe you made some very salient points about the plan. The CEQ draft report indicates funding for energy conservation program is not at an adequate level. But we had some witnesses yesterday who said there was a lack of well-defined projects to absorb additional funding.

What specific conservation areas does CEQ think should receive funding that is not presently in the budget or the plan?

Mr. JELLINEK. Mr. Chairman, let me point out in our assessment we have concentrated primarily on ERDA's planning and decisionmaking process, and the adequacy of that with respect to providing conservation opportunities, as well as focusing on supply technologies.

One way of indicating whether or not conservation is receiving appropriate attention is to take a look at the budget. We did that primarily as a way of indicating attention. We believe ERDA must pay more attention to the midterm and the long-term opportunities for conservation.

As I mentioned in my testimony, we think there is potential for opportunity for doing more research on advanced automotive engine systems and fuel cells and residential and commercial insulation and fuel programs. Those programs are not reflected in ERDA's plan or its budget today.

We did not go into the specific analysis—

Senator BUMPERS. That was going to be my next question. What long-term areas do you think are being neglected? I think you have pinpointed some. There, again, we have these turf fights up here, whether the Banking and Housing Committee is going to have the responsibility for this, or whether the Interior Committee will have responsibility for it. It is a case of everybody's business is nobody's business.

Mr. JELLINEK. It appears to us on the basis of what we know and some of the preliminary analysis that we have done, that conservation

opportunities may indeed be very cost effective. For a relatively smaller amount of investment you may be able to get a large amount of energy saving and in essence, conservation becomes a source of supply.

We think ERDA ought to do the kind of detailed analysis that will identify those costs and benefits, and compare those costs and benefits to its other R.D. & D. programs, and match each of them up equally and pick the ones most cost effective whether they be conservation, geothermal.

Senator BUMPERS. I could not agree with you more. That is what we are here to talk about.

Senator STONE. Mr. Jellinek, in your statement you mention a "no conservation" forecast of future energy use. This kind of yardstick of adequate attention to conservation in energy R.D. & D. alone cannot identify what energy conservation R.D. & D. should be done in competition with supply R.D. & D. A superior alternative would be to measure against the maximum feasible energy savings physically achievable, using principles of the second law of thermodynamics.

Are you implying by that, that the several scenarios that have been analyzed by ERDA more greatly emphasize no conservation or a moderate conservation approach than they do an all-out or greater conservation approach? Is that the implication?

Mr. JELLINEK. No; it is not. Before I go on to answer the question, let me say I am not sure of what report you are referring to. I have a pretty good idea of what it is—that looks familiar. But for the record, that is an early draft that is in the process of revision, and we are improving it. Although I might state, indeed, all of the major findings and conclusions are essentially the same.

Now, to get to your question. Our point was, as ERDA has built the various scenarios in the national plan, it did not look within each scenario as to what the possibilities for conservation were. It looked at one conservation scenario and then it looked at various other supply scenarios and so-called "combined" scenarios. Within the supply scenarios, it could not supply the possibilities of conservation to each scenario. That is No. 1.

No. 2, our point about the second law of thermodynamics recognizing the second law does not take economics into account, and recognizing that at certain points, certain practicability makes it difficult to achieve second law savings. The second law does provide a standard against which to target your program. It is nothing more than an objective goal.

We think it would be a useful mechanism to use in planning conservation programs, and we are not suggesting it is the only goal, the only mechanism, or the only standard, but it certainly provides one that can be very helpful.

Senator STONE. You testified there is insufficient coordination, step by step, between the Environmental Protection Agency and some environmental standards and ERDA, and by not deriving a coordinated set of environmental standards for pilot projects and demonstration projects and ongoing research projects, that environment and environmental standards have to play catchup instead of going along hand in hand.

Do you believe that requires legislation or do you believe the executive branch might be able to work out some form of periodic coordination itself?

Mr. JELLINEK. I think the executive branch and ERDA, in particular, is working to bring that about. I, frankly, cannot imagine just off the top of my head how legislation could solve the problem. I think it is a matter of devoting the resources and the manpower to developing environmental information and environmental standards at the same time as you are moving ahead with hardware development.

In ERDA's case, it is a management problem, and with respect to EPA it is a matter of both agencies getting together and working out some methods of cooperation.

Senator STONE. Be specific. If ERDA spends a little more of its resources on the environmental impact and the environmental planning of each of these projects as it goes, and if it and the Environmental Protection Agency set up a regular schedule of consultations to work on these standards, they would not necessarily be required to do so by some law. It is a question of picking up the phone and saying, "It is our time now. Let's get together."

Is that it?

Mr. JELLINEK. Yes. I think they are working toward this. I think that is the best way to work this out.

Senator STONE. Thank you, Mr. Chairman.

Senator BUMPERS. Thank you very much, Mr. Jellinek.

I understand you have an extensive statement you would like to submit for the record, Mr. Commoner. If you would like to summarize that statement, we will get into the question and answer session.

Is that right?

Professor COMMONER. I would appreciate that, Mr. Chairman.

STATEMENT OF PROF. BARRY COMMONER, DIRECTOR, CENTER FOR THE BIOLOGY OF NATURAL SYSTEMS, WASHINGTON UNIVERSITY

Professor COMMONER. As you have already pointed out, in the very short time ERDA has been existence, it has been authorized to spend nearly \$6 billion, and to spend \$6 billion on an extremely important program. I think it is important this overview should take place at this time. I am very glad to have this opportunity to participate.

I think we all know the Nation's energy problems are very serious and urgent. Everything we do depends on energy, and because energy has an absolutely unique relationship to our entire system of production, and, therefore, to the national economy.

I think we have to recognize, despite the urgency and importance of understanding how energy relates to the national welfare, we simply have not had an organized, rational, national energy program, and we did not even know it was missing until the oil embargo caught us.

It is also fair to say the establishment of ERDA represents the Nation's chief response to this lack, and, indeed, R.D. & D. is the first step toward creating rational policy. There is one point I want to make right away. We sometimes forget that research is designed, not only to answer questions, but first to discover what the questions are.

Until you ask the right questions and define the problem, there is no logical way to seek useful answers or to create a national policy that responds effectively to those problems.

If there is any general fault with ERDA, it is right there. They have not asked the questions. They have not looked for the right questions. I think, therefore, the policy they have established, thanks to the enormous momentum of the money adopted, really has no rational basis.

It seems to me ERDA has had two fundamental and inter-related possibilities as a government agency.

First, since it is the responsible agency in the energy area of research and technology, it ought to have the duty to assemble and analyze the known facts about energy so that the right questions can be asked and the relevant national problems can be defined. In other words, it ought to provide the information base for the creation of a national policy.

In the same sense, let's say the National Cancer Institute provides the information base for the establishment of national policy with respect to that disease. It has that responsibility.

The second thing, of course, is once the policy has been established, ERDA has the responsibility to organize the research and development to carry out its part of the policy. The main point about my testimony is to examine ERDA's actions, its plans against those two responsibilities, as I define them.

First, let's look at the question of how ERDA has defined the national energy problem. I do not mean to go through that in detail with you. It is clear, I am sure, from your analysis of the ERDA plan, that ERDA defines the problem basically as one of filling in the gap between domestic energy demand and domestic supply.

What it is worried about is the imported fuel, and that is the basic drive.

The next question I have to ask is what is the scientific reference for that definition of the Nation's energy problem? Although it is a scientific agency and therefore ERDA, it is presumed, reaches its conclusions on the basis of objective evidence, there is no scientific evidence in support of its evaluation of the national problem.

I looked very carefully for the references and what I found was a reference to an authority, namely President Ford, and you will find on page 4—no disrespect to the President and to his office—but I don't think that is an adequate source of authority on energy.

But on page 4, you will find laid out very carefully a quote from the President's energy message below that, and I will quote this. The plan says:

"It is the purpose of the National Plan for Energy R. & D. to translate these principles and goals into specific Federal programs for technology development * * *" and so on. There you have it.

ERDA got the message and established the program. As I say, with all due respect to President Ford, and for the office which he holds, I want to suggest that the President's analysis of the energy problem—which ERDA has adopted as its own—does not accurately reflect our current knowledge about the science and technology of energy and its relations to the national economy. There, I think, is the root cause of most of the faults in the ERDA plan.

What I would like to do is offer an alternative analysis, which is by no means complete, but I think is more adequately based on science than the one ERDA is following.

The main point I want to make—and I would like to quickly run through my thesis and offer some brief illustrations of the evidence—I think the main point I want to make, and I say this not out of any sense of antagonism or to indicate it was done deliberately, I really think if the ERDA plan were carried out, in my opinion it will become a blueprint for economic disaster.

This is the main point I want to make. I think they have stumbled into a brilliant technique for ruining the American economy, and let me explain why I think that.

I think the problem of the diminution of supplies of energy has to be regarded as basically an economic question. Let me point out to you, we say so many years' supply of oil, coal, et cetera—there is an awful lot of fuel you can get out of ordinary shale. The only trouble is it would be monumentally expensive. We could not afford to do it.

When you run out of a nonrenewable source, the expression of that physical fact is not that somebody suddenly shuts a door and there is no more fuel. The way you notice it is that the price of what you are after goes up. There are many examples. As we began to run out of whales, the price of whale oil went up. As people killed off egrets to get feathers, the price of egret feathers went up. Nobody said no more egret feathers. This is a very fundamental point which I think ERDA has missed.

The loss, the running out of a nonrenewable source—and of course energy, as we now use it, is such a thing—is translated automatically into an economic process. That process is the exponential rise in the cost of producing the energy which we sense as the price.

The main burden of what I have to say is we have to test the consequences of what ERDA has to do by looking at the exponential rise in the price of energy. I want to show you how that relates to what has happened.

The points I want to make—and I will run through them very quickly—is that there is now for the first time in the history of the United States a very rapid exponential rise in the price of energy relative to the rest of the economy.

In other words, we are in an energy situation, economically, which is absolutely unprecedented. The reason why this is serious is energy is not like egret feathers. You cannot get along without it. When ivory became scarce, plastics were put on piano keys. I don't know what was done when egret feathers became scarce, but apparently people got along without them. But you cannot get along without energy. There is no way of substituting anything else for energy.

The result is, as energy becomes more expensive so that the processes that use it become costly, you have no choice but to raise the price of the goods, which means a powerful impact on inflation, or to change the character of the production system, which means making capital goods obsolescent.

For example, I might point out the current trend, if it continues, with the public turning away from synthetic fabrics to cotton and wool, which has caused a beginning depression in the synthetic fabric industry, is a reflection of the fact the synthetic fabric industry is a very intensive user of energy.

If that fault becomes expressed economically, it will be an enormous loss to the country in the sense of the capital goods built up by the petrochemical industry, which will suddenly become, or be, a lot less.

The point I am making is we have to examine the ERDA plan in terms of what its proposed development of energy sources and uses will do to the rising price of energy. If the price continues to rise, we are going to be in very deep trouble.

Senator STONE. Mr. Chairman, can I interrupt with one question?

Are you suggesting when ERDA makes a proposal for research into an alternate fuel or any other energy-producing system, that the forecast of the economic cost be an integral part of that?

Professor COMMONER. Absolutely. It needs an economic impact statement.

Senator STONE. It is not whether you produce an alternative system but what it costs?

Professor COMMONER. Yes.

As an interesting thing, we have data that indicates how much organic fossil fuel must have been deposited in the Earth's surface from theoretical considerations. We also have crude estimates of how much we think we can find.

These latest figures indicate the amount of discoverable resources are probably 1,000 or less of the amount of carbon that must have been deposited as fossil fuel. Where is the rest of it? The rest of it is probably disseminated in the form of very dilute organic matter in things like shale in soil and so forth. It is there, but you could not afford to get it.

The point I am making is it is absolutely essential to understand nonrenewability expresses itself in real life as an economic factor. As I will point out in a moment, there is also an economic factor that is embedded in the design of the machinery that you use to transform the fuel into useful energy. I don't see how ERDA can possibly design any research and development without considering this economic factor, and I am afraid it has.

Incidentally, as in iron, one of Mr. Ford's prescriptions was to keep the cost of energy down, but that is the one prescription they did not nail to the wall and look at it. Everything they are doing is raising the cost of energy.

Now, energy is nonsubstitutive. What energy does is to yield work. This is true all over the universe. There is no way of getting along without energy if you want work done, and that is true whether it is done by people or by machines.

The simple point I want to make is when you try to get along with less energy, you lose the value of capital goods. I might point out, for example, the people who now own all-electric homes have to face the fact that home is worth less than they thought it was. Why? Because the operating costs have gone up and will go up. In other words, as the price of electricity rises, the capital value of a home totally dependent on electricity falls.

This is also going to be true of the auto factories that produce big cars as industry has to shift over to smaller ones.

Senator BUMPERS. It follows then, people who are making a bigger investment, to use as much solar energy in their homes right now will probably recoup that in increased value.

Professor COMMONER. You anticipate my response, but that is exactly the issue. That is the test we ought to place on any energy policy.

As I pointed out, there are two ways of responding to the situation. Either you let the price of energy go up and price-pass it through, through the production system, in which case the price of everything goes up.

If you don't do that, then you erode the value of capital goods.

Now that I have laid out what I think is the key issue, I want to direct your attention to figure 2 in my testimony, and that is what ought to be nailed up on the wall over ERDA. What this is, this is data, the Department of Commerce provides a price index for a series of goods and commodities and an average for all commodities.

What I have plotted here is the ratio between the wholesale price index for fuel and power, is the energy figure divided by the wholesale index price of all commodities. This ratio tells you how much you have to pay for energy relative to what you have to pay for everything else.

All we have done here is simply to plot the data right off the Department of Commerce tables. There are three separate indices actually. The data go back to 1811, but they are not too reliable.

But what you see is there has been a lot of scatter and so on, but the basic trend is, since 1930 there has been a steady decline in the relative price of energy, and in the period since World War II, which is the period in which our modern industrial and agricultural system has been created.

You know on the farm, for example, this is the time when fertilizer was introduced and so on. During essentially the building up of our modern industrial and agricultural production system, there has been a rather steady, slightly declining price of energy.

I do not want to suggest this has been an extremely important factor in the success of our industrial and agricultural development. In fact, just yesterday I noticed—I think it was in *Business Week*—an article about the current worries about one of the lagging economic indicators in what is supposed to be the recovery from the recession, and that is the expenditure of our capital goods.

There was a query to one of the industries of why they weren't spending for capital goods and the answer was uncertainty, and particularly the uncertainty about the availability and the price of energy. Energy is so important, the reliability of that economic input I think is extremely important to any entrepreneur.

In fact, the stability of energy up to 1973, I think must have had a very important effect on industrial development. If you look at the point at 1973, suddenly there is what can only be called a historic discontinuity in the price of energy. Any scientist looking at a graph like this, worries about what happened in 1973. We all know 1973 was the embargo. You might say, "Well, sure the price was increased because OPEC jacked up the price," but you will notice the price is rising at an almost constant rate in 1974, 1975, and we plotted the first quarter of 1976.

More important—and this is what I want to emphasize in a moment—it is inevitable that the price of energy will continue to escalate so long as we continue to use present forms of energy.

In other words, what I think has happened in 1973 is that OPEC anticipated the inevitable exponential rise in the price of energy and, in fact, the Shah of Iran has said that, has said over and over again, "What do you expect?"

This is not a renewable resource and of course the price is going up. We decided to make it go up at our choice, which had to do with politics and so on. So I think we have to regard this sudden rise as the inevitable consequence of our present pattern of the use of energy.

In other words, if we are using petroleum and natural gas, which is nonrenewable, as we take out a barrel of oil, the next barrel of oil becomes more expensive. You have to begin using secondary, tertiary methods, and so on.

I don't need to remind you about gas. Right now there is a big struggle about the price of gas. In other words, we are confronted with what I think can only be regarded as a very serious challenge to the stability of the major input into production. That is the price of energy.

I offer this as a background to what our problem is. Our problem is we are confronted with what may be a very serious and ultimately disastrous change in the price of energy. It seems to me the task of ERDA ought to be to devise ways of shifting from our present dependence on nonrenewable sources and techniques that tend toward rising the prices, shift away from those to a process of production and use of energy which stabilizes the price.

In other words, this figure 2, in future years we are going to have to flatten it out or else we are heading for disaster. If it keeps going up, we are in trouble.

What I have done is to analyze the ERDA plan from that point of view, and I can summarize very quickly to tell you if the ERDA plan is carried out, the price of energy will rise exponentially for the next 75 years, and I don't think we will make it. I don't see how we could possibly tolerate that.

Let me briefly give you the details. The near-term plan is based on enhanced recovery of domestic oil and gas. This means an enormous increase in the price of the fuel because you are using much more expensive techniques, but it is mainly based on light-water reactors.

I have included, as an appendix, a paper in which we have analyzed the relation between the nuclear power and the price of electricity. There is no question the price of uranium fuel will go up. As shown in figure 1B, it rises exponentially. 1A is the rise in price anticipated for natural gas and oil simply based on the diminishing returns of trying to get more and more out.

The same thing is true of uranium because, as the rich uranium ores are used up, you have to go to poorer ones, and that means much more refining and so on. So there is no way the present light-water power system could continue without a rapid rise in the price of the electricity produced.

In fact, the rising capital costs of nuclear power are already bringing us close to the crossover point as compared with coal-fired power. So the near-term plans of ERDA guarantee a rapid rise in the price of energy.

Well, let's look at the midterm plans. The midterm plans rely chiefly on coal conversion and shale oil. As I pointed out in table I, the capital

costs per unit of energy produced in shale oil and coal conversion processes are 10 times higher than mining coal. They are much higher than the capital cost of Btu of producing oil. In other words, there is no way of going into coal conversion and oil shale production without a rapid escalation in the price of fuel.

The figure that has been quoted, the last one I remember was \$26 a barrel, and you may remember Mr. Ford and Mr. Kissinger appealed to the OPEC nations to have a floor on the price of oil in order to encourage investors to go into shale oil and coal conversion.

As you know, that industry is in chaos now. They are unable to make the investments while the price of oil is still below \$26 a barrel. In other words, the promulgation of those ways of producing fuel is predicated on a \$26-a-barrel oil price.

There is no way of having these things effective unless the price of oil goes up.

I might mention one of the problems is I don't think they really understand—

Senator BUMPERS. May I interrupt you? You are talking about \$26 a barrel. You are talking about oil shale and coal conversion?

Professor COMMONER. Yes. They are roughly comparable figures although there is a good deal of variation depending on how some of the pilot plans come out, but the last figure I remember—I think that was synthetic fuel—is \$26 a barrel; shale oil, there are some techniques they could work that would be a little lower.

Senator BUMPERS. Occidental is insisting that will be much, much lower.

Professor COMMONER. Occidental has not faced the fact that shale oil is carcinogenic. This has been known since 1896. The CEQ people referred to that. That is an extremely important point and I looked carefully through the ERDA plan and found no mention of it. I was a little put out about it. I had gone to ERDA at their invitation about a year ago, and gave a seminar on that problem.

Senator BUMPERS. There is no mention of that?

Professor COMMONER. There is no mention and there must have been 50 people on that staff when we presented our scientific data. In fact, I showed them an analysis of a synthetic oil sample we had gotten from the group at Oak Ridge that we had analyzed, and it clearly had carcinogenic materials.

Some of the staff I think really appreciated it, but I think the impact of this, as the testimony just before me has pointed out, has not really become embedded in the thinking of planning at ERDA. This means they are dealing with a problem very much like nuclear power where unexpected technological difficulties arise, and they keep escalating the cost.

I think before we are through, if we are going to use coal conversion, there will be problems like putting it in an air-tight seal to prevent dissemination of volatile carcinogenic materials.

The main plant operating in West Virginia, operated by Union Carbide—after 6 years it was shut down. The workers had something like 30 times the expected incidence of skin cancer.

Senator BUMPERS. I had heard with the process the Germans used in World War II that every worker came down with cancer.

Professor COMMONER. I have not seen those data, but the West Virginia data is a classical example of good scientific work. The medical department of that plant got alerted to it because a study had been done just after the plant started. They rubbed products of the plant on the skin of mice, and in 9 months or 1 year, there were tumors, and immediately the medical department clamped down. There is a series of very good papers.

For example, when ever a worker had a blemish on his skin, he was required to come in and was photographed at weekly intervals. They really monitored those workers. There was a lot of hygiene. They were warned about washing and so on. Yet, after 6 years, a very short time, there was something like a thirtyfold excess rate of the incidence of skin cancer.

Senator BUMPERS. Was most of that skin cancer?

Professor COMMONER. Yes; and you understand most of these are polycyclic aromatics which dissolve in the oil on the skin, and the organ at risk is the skin.

This is something we have pointed out repeatedly. One of the organizations I am associated with, the Institute for Public Information, sent one of our people to a hearing—I forget which one—at which Mr. Seamans was present, and when the young lady got up to mention or ask about carcinogenicity, there was a good deal of objection this was irrelevant, and so on. It is not irrelevant. I think it is going to affect the price of what they are trying to do.

The point I am making, the midterm plan, based on coal conversion and oil shale, will again increase the price of energy. The long-term plan will do the same. The long-term plan is based on what they regard as possibly three possible renewable sources of energy.

Let me say very quickly, if you want to think about our key question, the price, you will have to think about a key sequence of two steps: The source and the machinery converting the source of energy into useful work. In order for the price not to escalate, the source has to be renewable. That is clear.

If it is not renewable, then no matter what kind of machines you use, the price will go up. That is the trouble with an oil burner. An oil burner is a good, economic machine, but the oil burner is going to go up in price repeatedly, and the same way with gas furnaces.

The second question is what about the machine, is that going to go up in price? Nuclear reactors are going up in capital costs, escalating rapidly. So unless you contain both problems, unless you have an inexhaustible source of fuel and what I like to call a mature technology like an oil burner—we know enough about oil burners so the price does not go up because of unexpected peculiarities—but unless you have a mature technology and an inexhaustible technology, the cost will go up.

ERDA proposes three possible inexhaustible energy resources. One is based on the breeder, the other is fusion, and the third is solar energy. I think fusion we might as well drop immediately in the discussion here because no one even knows whether it will work. It is already clear the capital costs will be enormous. It is going to take a very long time before this nonexistent process becomes mature. So I am not going to say any more about it.

The breeder is an excessively immature technology. In the first place, it now seems the breeders in England and France, which are usually referred to as examples of the success of the technology, in fact do not breed. The Soviet breeder is now operating at two-thirds capacity. I don't know of any evidence for or against as breeding. The difficulty is it takes very close tolerances in the arrangement of the fuel elements to get breeding. Those close tolerances make the safety devices that have been forced on conventional nuclear powerplants very difficult to use in a breeder.

In other words, this is a very much unresolved technological issue, and for that reason there is no chance it is going to become mature in the sense of not rising in price for a very long time.

The other point I might make is I have actually taken an AEC data of when they expect breeders to produce—if they do—produce enough fuel to run the expected light-water reactors, and figure 6 spells that out.

What that shows very simply is even if everything works in the breeder plant, it will not be until something like 2040 that you will be able to get away from natural uranium supplies to run the nuclear power program.

That means the exponential rise in the cost—

Senator BUMPERS. Let's go back. I didn't quite track you on that.

Professor COMMONER. If you want to look at figure 6, it will help. Figure 6 is the scheme—well, let me go back for a moment. The present nuclear power system is a one-pass use of uranium. Therefore, as the cost of uranium rises, natural uranium, the price of energy, electricity, will go up. This was recognized by the AEC 10 years ago. That is why they introduced the breeder. The breeder was introduced to get away from the diminishing supplies of natural uranium. It would reproduce cycling of uranium and extend the supplies for years.

All right. Let's accept that. Now, let's ask when do you expect to have enough bred, artificially bred fuel to run the nuclear power program you think you are going to build up, and figure 6 explains that.

The top figure is the total demand for fuel, including you need fuel to start the breeders going. So that is the total demand, the demand curve.

The second, B, is the expected production of plutonium in the breeders if everything works. What you have to do is subtract the second curve from the first in order to find out much natural fuel you need, and it turns out you are going to need natural fuel until around 2040. Natural fuel will escalate in price as it is used. Therefore, the entire nuclear program is not free of that impulse toward a higher price in 2040 until the very earliest. That is the point I am making.

Senator BUMPERS. I follow you now.

Professor COMMONER. I want to finish now by saying that almost without exception—and I do not need to go into the figures, you already know—the major expenditures in the ERDA plan are for nuclear power, coal conversion, shale oil, and so on.

Those expenditures are all for energy production techniques which are bound to raise the price of energy. That is why I think it is a prescription for disaster. They are moving toward the production of energy which will continue this historically new fact that the price of energy is rising, and as far as I can tell, if the ERDA plan goes

through and we actually become dependent on shale oil, nuclear power breeders, and so on, what will happen is the price of energy will rise relative to the rest of the economy for 75 years. I would like to see a professional economist tell us how we are going to survive that. I do not think it is possible.

Now we come to the question of can we do anything about it. As it turns out, as you have anticipated, that the only way to get both an inexhaustible source of energy and a mature technology is to turn to solar energy.

The first point I want to make is we now have for space heat and hot water a mature technology, economically competitive. One of the appendices I have enclosed shows by properly mixing solar and conventional sources, you can today save money in producing hot water in St. Louis, counting the amortization of the investment, the whole works.

In the next year or two, in most parts of the country, it will be possible for a householder, if someone would lend them the money, to afford and save money by introducing partial dependence on solar energy for space heat and hot water.

I want to mention a new technology, which has been developed at MIT, which provides both hot water and electricity, a very clever way of using a solar photovoltaic cell. This will provide for 80 percent of the space heat and hot water for areas south of Washington State, and more than half of the electric needs.

What it says is we could start now to flatten out that price curve. Why would it do it? You do not pay for fuel, and the price of the equipment will not rise; in fact, it will fall as mass production begins. In other words, there is an instance where we can flatten out the price and, incidentally, this becomes a hedge against inflation. You are investing in something which will reduce your expenditures for something that is going to be higher priced later on, namely, fuel.

The other solar technologies, some of them are close to mature. I think that is true of wind energy. The price of photovoltaic cells is falling; it is not going up. But I want to emphasize it is the slope of the curve. If the technology becomes increasingly expensive, you are in trouble. If it is flat or falling, you at least know you are going to get to a point where you can flatten out the price of energy.

Ocean thermal is a project at Johns Hopkins which now claims to be able to produce ammonia competitively from the solar energy available from the temperature differences in the ocean. Ammonia is one of the most energy-intensive supplies we use now. I see no reason why we could not turn the entire program around and depend on solar energy and coal combustion in the interim in order to get a national energy plan that involves steady prices of energy.

This is exactly the reverse of the ERDA plan and it is something that is already clear. I see no way of our achieving any sensible energy policy without a total reorganization, a 180-degree turn from the direction ERDA has taken. I hope these hearings will perhaps make them take the first step in that direction.

Senator BUMPERS. Dr. Commoner, I so totally agree with everything you have said, I don't know what kind of questions to ask you.

What you have said makes such eminent good sense it seems that the power industry present will take issue with what you have said, but it seems almost infallible to my native intelligence.

I am not a scientist or an economist, but my native intelligence tells me everything you have said is precisely correct and I would not profess and I would not say here with a straight face that I have read all of ERDA's plan. I have not. But everybody I have talked to that has, that I consider to be totally objective about it, has said very much what you have said about the cost effectiveness of the programs we are talking about.

Your opening statement was that it was a prescription for economic disaster, and I think you have fortified that statement as precisely as possible. It points out Congress cannot, without cost-effective options, assist ERDA in these choices.

Professor COMMONER. ERDA has not given you the information you need to make that estimation. That is the problem. You should have gotten from ERDA some of the graphs I have produced in my testimony. It is silly for someone back in St. Louis to have to struggle through the Department of Commerce data. They should have done that a long time ago.

Senator BUMPERS. I don't see how they can design a plan without it, to be frank with you.

The most persuasive and interesting graph, of course, is this historical cost of energy in the country, and I think it is fairly easy to predict. Who can argue with the fact if we continue to rely on finite resources that the cost is not going to go up. It is like the whale oil. In any event, I am going to try to arrange to get a transcript of what you have just said, not in your formal statement, but what you have said informally here today, get that transcribed, and get it in the hands of every Member of the U.S. Senate.

Our priorities around here get mixed up. I regret every member of the committee is not here this morning, but they will have access to what I think is one of the most compelling cases that has ever been made for a gigantic leap into energy sources that are not finite.

I thought your conclusion was perhaps one of the most interesting. That is, we can start right now with a mix that would have a salutary effect.

Professor COMMONER. The University of Illinois has done a translation of our analysis for five typical homes in Illinois. They want to prepare a brochure for builders in Illinois, and homeowners, to show how this mix can be achieved today in Illinois.

In other words, there is no reason why it cannot go, short of financing, and the financing will have a payback point of perhaps 10 or 12 years. It is a question of the Government having the will and the wit to put its money there.

Senator BUMPERS. The suggested question is should ERDA be doing the same thing in demonstration projects?

Professor COMMONER. Absolutely. I think it has been pointed out in OTA in criticism that ERDA has been technology minded and has not looked at the system.

One of my favorite topics I did not talk about, thermodynamics, but there was an absolute historic analysis of our energy system made by a group from the American Physical Society 2 years ago. They are the ones who pointed out although engineers always use the second law of thermodynamics in designing a powerplant, they did not ask the question about the second law when they hooked up the powerplant to people's homes.

So, for example, the second law of efficiency of electric home heat is less than 1 percent. You never hear that in the television ads. So the power company very carefully has its engineers use the second law inside the plant, but it never lets its customers in on that secret.

It seems to me—and this was a beautiful piece of work, the APS study. I carefully went through every ERDA document I could lay my hands on to find out if they knew or acknowledge the existence of that APS study. It is nowhere in sight.

That is one of the faults of ERDA, again. It is not in touch with the scientific community. Every one of us in science or many of us were enormously impressed with the study. It was a beautiful piece of work. It lays out for the first time the way in which we can use the science of thermodynamics to make drastic improvements in energy conservation.

You would have thought ERDA would alert the Members of Congress to that. Literally, what should have happened when that APS study was published. ERDA, as the responsible scientific agency in the Government, I think, should have digested it, explained what it meant, and sent that to the administration, to every Member of Congress. I think it is a disgrace that that did not happen.

Again, it is not facing its responsibility to do an objective analysis of this enormously important problem.

Senator BUMPERS. Dr. Commoner, I would say there are three or four questions that may occur to me later, which is usually the case, that I would like to submit to you in writing just informally for my own personal use, but probably to go in this record also.

I cannot tell you how much I have appreciated your being here and your testimony this morning.

Thank you so much.

Professor COMMONER. Thank you.

[The prepared statement of Professor Commoner follows:]

Testimony before
The Subcommittee on Energy Research and
Water Resources of the
U.S. Senate Committee on Interior and
Insular Affairs Hearings
on
The Energy Research and Development
Administration's National Energy Plan

Washington, D.C.
July 29, 1976

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Introduction

In the short time since it was formed, ERDA has published two comprehensive plans for research and development designed to solve the nation's crucial energy problems. The agency has thus far been authorized to spend a total of \$5.9 billion for that purpose (i.e., excluding military activities). It would seem appropriate, and indeed necessary, at this time to examine ERDA's record and to determine whether this massive and costly effort is in fact proceeding along a course which is likely to meet the nation's energy needs.

The nation's energy problems are serious and urgent. Every human activity--agriculture, industry, transportation, communication, and indeed our very bodily survival--is absolutely dependent on work, and therefore on energy, which is the unique source of work. Because of this relationship energy is intimately connected with the design of the system of production and exerts a powerful effect on the entire economy. But, despite the enormous importance of energy to national welfare, we have had no discernible national energy policy, and were even unaware of its absence until that was forcibly impressed upon us by the oil embargo of 1973.

The establishment of ERDA was the nation's chief response to this lack, recognizing that a plan of research and development is the essential first step toward creating a national energy policy. We sometimes forget that research is designed not merely to answer questions but, first, to discover

what the questions are. And until the right questions are asked and the problems are defined there is no logical way to seek useful answers or to create a national policy that responds effectively to the problems.

Accordingly, ERDA has had two basic and interrelated duties: (a) as the responsible government agency in the area of energy science and technology, to assemble and analyze the known facts about energy so that the right questions can be asked, the relevant national problems can be defined, and a national policy based on solving them adopted; (b) to organize research and development activities designed to implement this aim. It is my purpose in this testimony to test ERDA's accomplishments against these requirements.

How has ERDA defined the national energy problem?

According to ERDA the basic problem is that we depend on foreign energy supplies to fill the gap between the national demand for energy and the domestic supply of energy. This position is set forth, in Chapter I ("The National Energy Problem and the Nature of its Solution") of ERDA's 1976 plan, "A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future", as follows:

"The United States is a nation rich in domestic energy resources, yet depends on the importation of large quantities of fossil fuels. This is the essential paradox of the Nation's energy problem" (p. 15).

More specifically, the Executive Summary states:

"The Nation faces a serious and continuing energy problem characterized by limited energy choices and increasing dependence on diminishing oil and gas resources. This problem is currently exemplified by an undue reliance upon imported fuels...Actions must be initiated to prepare for a transition from dependence on oil and gas to reliance on alternative energy sources, particularly coal and nuclear in the near and mid term... To provide alternatives to undesirable dependence on oil and gas, the Nation must undertake a program of technology development which will be technologically difficult and costly, and will require time" (p. 2).

Although ERDA is a scientific agency and therefore may be presumed to reach conclusions on the basis of objective evidence, it cites no scientific references in support of the foregoing evaluation of the national energy problem. Rather, the guiding authority for ERDA's analysis appears to be President Ford:

"...The President set forth the following goals for a comprehensive national energy effort in the 1976 Energy Message:

- First, to halt our growing dependence on imported oil during the next few critical years.
- Second, to attain energy independence by 1985 by achieving invulnerability to disruptions caused by oil import embargoes...
- Third, to mobilize our technology and resources to supply a significant share of the free world's energy needs beyond 1985.

It is the purpose of the National Plan for Energy R & D to translate these principles and goals into specific Federal programs for technology development, recognizing that industry initiatives in implementing this development will be of paramount importance, and that the public's support as citizens and consumers is essential" (p. 4).

With all due respect to President Ford, and for the office which he holds, I suggest that the President's analysis of the

energy problem--which ERDA has adopted as its own--does not accurately reflect our current knowledge about the science and technology of energy and its relations to the national economy. Accordingly, in reviewing the ERDA Plan, I should like to begin by supplying what in my opinion is a more appropriate view of the problem.

Since 1973 there has been a sharp increase in the price of energy. The conventional response is that we are, after all, "running out" of energy; that it has been "under-priced"; and that we will simply have to learn how to live with higher energy prices in the future.

In contrast, it is the burden of my testimony that the real issue is not that we are running out of energy but that we are running out of our ability to pay for it; that the present, very rapid rise in the relative price of energy (i.e., as compared with the price of all commodities) is unprecedented in the history of modern agricultural and industrial development; that because energy is a unique and irreplaceable input to every production process, the entire system of production and the economy that depends on it will be seriously disrupted if the energy price rise continues; that not only energy problems but also the problems of environmental quality and unemployment mandate considerable changes in the production system, which must be made in an orderly fashion if catastrophic effects on the national economy

and public welfare are to be avoided; that the inherent properties of the energy sources and technologies which dominate the present U.S. energy system can only continue and worsen the rising price of energy and thereby disrupt orderly changes in the production system; that the essential task of national energy policy ought to be to slow down the rise in the price of energy and to stabilize it as soon as possible by fostering the development of appropriate energy technologies in place of present ones; and that ERDA's plan for the development of energy sources and technologies--if allowed to proceed--will not only fail to accomplish this aim, but will actually help to defeat it.

In what follows I shall expand on these basic ideas and outline the evidence from which they are derived.

The Energy Problem

Let us begin with some basic facts about the nature of energy and its role in the national economy. Energy is a resource, which like all resources is valuable because it is a major input --along with raw materials, capital and labor--to the production of useful goods and services. The role that such an input plays in the production system depends on its relative price--a feature which it shares with all inputs--and also on the special part that each particular input plays in the processes of production.

Like the price of any other resource, the price of energy depends on the ability of supply to keep pace with demand. When the supply is limited--as in the case of fossil

fuels and uranium--the price is certain to rise at a constantly increasing rate (that is, exponentially) as soon as the physical limits begin to affect the ease with which the energy source can be produced. Then, as each barrel of oil is taken out of the ground it becomes more difficult and more costly to produce the next barrel; as the richer deposits of uranium are exhausted and leaner ones need to be used, the cost of mining and refining increases. Because the supply is limited, the law of diminishing returns is at work, and the price of the energy resource is bound to rise progressively with time as the resource is exploited (see Figure 1 for examples).

There is nothing new or surprising about this economic process. This is what happened to the price of ivory as ivory hunters began to kill off the source of supply--elephants; the same thing has happened, for the same reason, to the price of whale oil and egret feathers.

The natural, rational response to such trends in the price of a nonrenewable resource, or production input, is substitution. Substitutes for ivory, whale oil and egret feathers were found, which can serve essentially the same productive function but are more plentiful and therefore cheaper. Some adjustments need to be made in the production process, but these are usually minor. When ivory buttons were replaced by mother-of-pearl buttons, and both later by plastic ones, the same sort of sewing operation could be used to attach them.

By substituting the more plentiful input it was possible to keep the price of the finished product from rising progressively as the original input became increasingly scarce and expensive.

However, there is a very important difference between energy and all other resources: Unlike other major resources there is no substitute for energy. Energy is uniquely the source of all the work done in the production system (or for that matter, in the universe). If energy becomes too costly and less of it must be used in production, the design of the production process itself must be changed.

Recent events provide illuminating examples of this contrast between energy and other resources. When, because of cost differentials, the auto industry replaced natural rubber with synthetic rubber, the industry was able to make the substitution without any significant changes in tire-manufacturing equipment, or for that matter in the construction of the vehicles themselves. The shift from iron engine blocks to aluminum ones was made with similar ease. In contrast, the recent increase in the price of gasoline, which motivates reduced gasoline consumption, precipitated a vast and disruptive shift in the design of passenger cars. As this transformation progresses it will require a basic retooling of the manufacturing plants themselves, since the relative unprofitability of the small cars mandated by energy conservation will encourage further automation of manufacturing. The design of a vehicle, and

therefore the machines used to manufacture it, will be more profoundly affected by the availability of energy than by the availability of other, non-unique resources.

When a production factor forces redesign of the means of production it has a profound effect on the economics of production. Production machinery is characteristically so expensive that its economic value depends on a relatively long life, usually measured in decades. If a production machine is abandoned before the end of its useful life because a change in the cost of an irreplaceable input, such as energy, has made the very process itself uneconomic, a heavy loss in the value of the capital goods is incurred. An analogous example which has begun seriously to affect many homeowners is the "all-electric home". Such a home is now worth less, relative to the value of less-electrified homes, than it was before the price of electricity began to rise, because its owner faces sharply increasing operation costs. In effect, a persistently rising cost of energy generates a powerful force toward the obsolescence of capital goods; it diminishes the value of existing production equipment which was designed on the basis of an earlier, lower cost of energy. Thus, the conventional wisdom that energy has been "underpriced" puts a seemingly routine face on a process that is, in fact, a seriously disruptive influence on the economy.

It is clear, then, that energy cannot be treated as though it were merely a resource that contributes only to the

overall cost of production. Energy is a unique resource which powerfully affects the value of the capital goods that are invested in nearly all production processes.

There are two possible ways of accommodating to a rising overall price of energy. One way is to allow the price rise to "pass-through" to the final product. Since energy is required for every product and service, this means a general price increase. Rising energy prices would superimpose, on existing inflationary trends, an added pressure that could become a serious threat to economic stability, and a growing burden on the U.S. people.

An alternative way of responding to the rising price of energy is simply to use less of it in production or to cut down on the production of energy-intensive goods. This is the method generally favored by those who expect the "free market economy" to automatically adjust to resource shortages by means of the price mechanism. However, this expectation overlooks the basic fact that energy--unique among resources--is absolutely, universally irreplaceable. Therefore, any effort to reduce the input of energy in a production process or to replace the manufacture of energy-intensive products is very likely to require the considerable replacement of existing production machinery--leading to the losses associated with enforced obsolescence of capital goods. Serious problems that have already arisen because of the "capital shortage"--the expected shortfall of capital needed for industrial production in the next decade. Obsolescence of capital goods due to a rising energy price would considerably worsen this problem.

Thus, because of its unique and close relation to production, energy has a distinctive economic effect: if its price takes off on a progressively upward trend, it will tend to impose a powerful inflationary pressure on the entire economy, either by raising the prices of finished goods, by eroding the value of capital goods, or both.

Against this background it is illuminating to examine the actual trends in energy price during the development of the modern U.S. production system. This is shown in Figure 2, in which the price of energy (expressed in uninflated terms, relative to the current price of all goods and commodities) is plotted, annually, from 1900 to the present. The price has often fluctuated a good deal, depending on supply/demand relationships as they are affected by factors such as production technology, labor disputes and periods of depression. Nevertheless, certain general trends are clear. Apart from considerable fluctuations between 1900 and 1920, and a brief rise at the end of that period (probably a result of mine strikes and otherwise chaotic economic conditions in 1919 and 1920) there has been a persistent downward trend in the relative price of energy in the 70 years preceding 1973. Since World War II, energy prices have been nearly constant.

The relation between energy price trends and the rate of industrial development is particularly significant. Between 1920 and 1973, as the price of energy fell, the use of energy

increased by about 250 percent, and industrial production increased by more than 700 percent. The period 1945-73 is particularly important because it was in this period, in which energy prices remained essentially constant, that the massive post-war build-up in industrial production--involving a three-fold increase in capital goods--occurred. Similar changes have occurred in agriculture; between 1940 and 1970 energy consumption increased by about 320 percent, production by about 54 percent, and capital equipment by about 147 percent.

Thus, in the entire history of modern industrial and agricultural development in the U.S.--up to 1973--relative energy prices have either decreased or remained essentially constant. As a result, new productive machinery could be introduced without incurring the risk of early obsolescence due to rising energy prices or the disruptive effects of energy-induced inflation. It seems likely that the relative stability of energy prices--or at least the absence of sharp increases--contributed a good deal to the feasibility of the massive development of the U.S. production system that occurred in the post-war period.

In that same period the falling price of energy encouraged the development of energy-intensive production technologies, with the most energy-intensive industries (such as chemicals) growing most rapidly. As a result, the U.S. production system is now mainly based on technologies that are particularly

vulnerable to the economic disruptions that are inevitable if the price of energy takes off on a long-term climb.

Against this background, the events since 1973 take on an ominous significance. The sharp and continuing rise in the price of energy since 1973, which is evident in Figure 2, is wholly unprecedented in the history of the modern U.S. production system. (A statistical computation based on the data of Figure 2 indicate that there is less than one chance in a thousand that the post-1973 increase could have occurred as a result of random fluctuations in price.) The immediate cause of the initial increase in the price of energy was the 1973 embargo, and the rise in the price of oil imposed by the OPEC countries. However, the price rise has continued with no appreciable reduction in rate since the end of the embargo. This continued rise reflects the basic fact that the sources of energy on which we largely depend, especially petroleum and natural gas, are nonrenewable and for that reason are certain, at some point, to begin to increase in price at an accelerating rate. It is this fact (often expressed, for example, by the Shah of Iran) that has given force to OPEC's drive for higher oil prices. Thus, OPEC actions served only as an abrupt and perhaps anticipatory means of bringing the inherently inflationary impact of the nonrenewability of our present energy sources into play.

The rapidly rising price of energy reflects another important fact about the U.S. system of energy production: It has been based increasingly on technologies of energy transformation (which is essential to apply the energy contained in a particular source effectively to given tasks) that are particularly expensive, such as electric power production, in particular by nuclear plants.

Finally, the rising price of energy has been affected by the rapid growth in the demand for energy, which, in turn, has been strongly influenced by the substitution, especially since 1945, of production technologies that use energy inefficiently (for example the production of synthetic fibers and plastics, or the use of trucks to haul freight) for older technologies that used energy much more efficiently (for example the production of natural fibers and leather, or the use of railroads to haul freight). As I have pointed out in some detail (see The Closing Circle, Knopf, 1971, and The Poverty of Power, Knopf, 1976), this technological transformation is responsible for not only the inefficient use of energy, but also the excessive impact on the environment and a good deal of recent unemployment.

Here, then, in grim outline, is the basic energy problem that the nation now faces: For the first time in the history of modern agricultural and industrial development we are in the midst of a rapid and continuing increase in the price of

energy--a phenomenon which, because of the unique role that energy plays in the production system, will have catastrophic economic effects if it is allowed to continue. The basic problem is to learn how to slow this unprecedented rise in the price of energy, and to stabilize it. Only then can the necessary changes in the energy system and in agriculture and industrial production that are mandated by the environmental and energy crises be made in an orderly way, that protects the people of the U.S. from the corrosive effects of inflation and unemployment.

The ERDA Plan

This requires answers, based on an analysis of the fundamental properties of energy and their relation to agricultural and industrial production, to a series of crucial questions: How can energy be produced from sources that are renewable and therefore not subject to the economic effects of diminishing returns? How can energy be transformed by technologies that are thrifty in their costs, relative to the amounts of useful energy they yield? How can energy be more efficiently applied to agricultural and industrial production, and transportation? These questions define the task of energy research and development, and therefore the responsibilities of ERDA.

This definition of the nation's energy problem, which, I believe, reflects fairly well the available scientific

evidence, contrasts sharply with the definition put forward in the ERDA plan, which appears to be based on the President's analysis of the problem. It comes as no surprise, then, that the ERDA plan itself should fail to accomplish the essential task, as I have defined it, of fostering research and development on those features of energy technology that promise to help stabilize the price of energy.

The ERDA plan not only fails to accomplish this essential task, but tragically--if allowed to proceed--will only worsen the present, potentially catastrophic energy price trend. An analysis of the ERDA plan shows that most of its major programs would lead to the development of energy technologies characterized by a powerful, inherent tendency to continue the present rise in energy prices for as long as 75 years--a stress which the U.S. economic system is unlikely to endure for even a fraction of that time. This is evident from the following.

The Near-Term Plan

In the near term ("now to 1985 and beyond"), with respect to energy production, the ERDA plan proposes to rely on enhanced recovery of domestic oil and gas and increased production of nuclear power. Enhanced recovery of oil and gas will, of course, involve considerably increased production costs and inevitably lead to higher prices--as frequently pointed out by the oil industry in appeals for the necessary "incentives."

In the near term ERDA also proposes to stimulate the growth of fission nuclear power, which--once more--means a sharp increase in future energy prices. One reason is the expected escalation of the price of power from nuclear plants, as compared to the price of power from coal-fired plants. As shown in Figure 3, and in more detail in the attached document (Appendix I), this results from the recent tendency of the capital costs of nuclear plants to rise faster than the capital costs of coal-fired plants. Figure 4 shows the same trend in capital, fuel and other costs of nuclear power since 1966. Further evidence of the expected rise of the price of nuclear power is that present enrichment facilities are approaching their capacity, and that the recent proposal to build additional facilities based on private investment would involve a three-fold increase in the present enrichment fee. In addition, the handling of reactor wastes is certain to become more expensive. A recent ERDA report shows that because there are no ultimate storage facilities for high-level radioactive wastes, new temporary facilities will need to be constructed--adding to reactor operating costs. Finally, it is evident that the nuclear power program will need to incur considerable new expenses if and when an acceptable means of "final" disposal of high-level wastes is developed. The heavy emphasis in the ERDA plan for research and development is directed toward the rapid growth of nuclear power, as it takes over a higher proportion of total

power production. For the reasons cited above, this program --if it succeeds--will lead to a continuous increase in power prices.

In addition, apart from the problem of enrichment, there is the complex matter of the availability and price of nuclear fuel itself. Natural fissionable ores are a limited resource, which will increase in price exponentially as they are progressively consumed (see Figure 1B). The present U.S. nuclear power system is based on the one-way use of natural fissionable fuel by light-water reactors (LWR). If ERDA projections for expansion of nuclear power production (which is scheduled to increase 12-fold between 1976 and 2000) were based on these reactors, fuel prices would escalate continuously, adding to the rising price of nuclear power incurred by increasing capital costs. It is this serious economic problem, which was recognized by the AEC over ten years ago, that has led to the development of the breeder program. However, as will be shown below, the breeder program--even if it should meet ERDA's expectations of success--will not, in fact, prevent the rapid escalation of the price of nuclear power for at least 65 years, which will be far too late to avoid economic catastrophe.

The ERDA near-term plan also lists research on improved direct combustion of coal, and combustion of waste materials, as means of enhancing energy production. However, in the ERDA 1977 budget these programs account for expenditures of slightly

more than \$55 million, as compared with a total of about \$880 million devoted to activities required for near-term support of nuclear power (\$280 million for fuel cycle and safeguards; \$575 million for enrichment; \$10 million for LWR development; and \$15 million for nuclear environmental control technology) and \$31 million for enhanced oil and gas recovery. Thus it would appear that ERDA plans to rely on nuclear power and enhanced oil and gas recovery, particularly the former, to increase near-term energy supplies. In practice, then, the ERDA near-term plans are based on programs that are certain to continue the present, rapidly rising trend in energy prices.

The Mid-Term Plan

In the mid-term ("1985 to 2000 and beyond") ERDA proposes to rely on coal conversion and shale oil to provide the liquid and gaseous fuels needed to replace petroleum imports and dwindling domestic production of petroleum and natural gas. As can be seen in Table I, the capital costs (per unit of energy produced) of coal conversion and shale oil processes are about ten times that of coal mining itself and well above that of even intensified petroleum production. As a result, coal conversion and shale oil products are expected to be sold at well above present fuel prices; prices equivalent to \$26 per barrel of oil are frequently cited. Moreover, the present estimates of production costs are bound to increase even more as environmental effects that have not yet figured in cost

computations--in particular, the need to remedy the tendency of these processes to produce carcinogenic materials--are taken into account. This means that the introduction of coal conversion products will involve a sharp increase in fuel prices which will worsen progressively if these products increasingly take over the present functions of natural gas and petroleum.

In sum, if the ERDA plans for near and mid-term development of energy sources were actually carried out, it would mean that "from now to 2000 and beyond," coal conversion products and shale oil would displace natural gas and petroleum, and nuclear power would provide an increasing proportion of total power production. The introduction of these more expensive forms of energy would continue the present, rapid rise in energy price for at least 25 years--placing an intolerable pressure on the economy.

The Long-Term Plan

Will ERDA plans for the development of longer-term ("beyond 2000") energy sources bring eventual relief from this economic problem? In the ERDA plan, reliance on three possible "essentially inexhaustible energy sources" is proposed as a means of achieving long-term "energy independence": extension of the natural nuclear fuel supply through the breeder program, fusion, and solar energy. Judging the relative importance which ERDA attaches to these sources from the expenditures proposed in the 1977 budget (breeder development, about \$620 million;

fusion research, about \$304 million, solar research and development, \$116 million) it would appear that the nuclear technologies are to be relied on to provide most of the long-term "inexhaustible" sources of energy.

If an energy source is indeed "inexhaustible" then the economic constraints of the law of diminishing returns do not apply and one can expect that the original source of the energy (regenerated plutonium, deuterium, and sunlight) will not increase in cost as production expands--making it possible to achieve stable energy prices.

However, before an energy source can be used, it must be transformed by some kind of machine, such as an ordinary oil-burner or a nuclear reactor. The cost of this machinery will, of course, also contribute to the final price of the useful energy that is produced. Even if the original source of energy is essentially unlimited--so that it is not subject to the law of diminishing returns--if the cost of the machinery needed to exploit that energy source increases from year to year, the price of the energy will follow a similar upward trend.

In turn, the time-trend in the cost of energy-transforming machinery depends on the newness of the the technology and its intrinsic complexity. Thus, an oil-burner is an old, well-established, "mature" technology, and its cost has been relatively constant in recent years (i.e., compared with prices generally). In contrast, nuclear power is a new and very

complex technology which is still in the process of being altered in design, in particular to meet requirements for safety and environmental protection that were not anticipated in the original design. In this sense nuclear technology is not "mature," and its capital costs (relative to prices generally) have risen sharply since it was first developed (see Figures 3, 4, and 5).

It is also apparent that breeder technology is far from mature, being confronted with a number of very severe, unsolved problems. In particular there is the conflict between the safety of a reactor and its ability to "breed" and actually produce new nuclear fuel as it generates power. Breeding depends on tolerances in the structure of the fuel elements that are so close as to make the safety features that have been adopted in present reactors very difficult and perhaps impossible to apply. Indeed, it is now known that the breeders operating in France and England, which are often cited as evidence of the successful development of the technology, are not, in fact, breeding; apparently this crucial design problem has not yet been solved in these reactors. The Soviet breeder is reported to be operating at two-thirds of its rated power output as a result of technical difficulties, and it is not known whether or not it is actually "breeding."

That such unresolved technological questions are also inherent in the U.S. breeder program is evident from the rapidly escalating projections of the cost of the program,

which increased from about \$2 billion in 1970 to \$10.7 billion at present. Taking these problems into account, and considering ERDA's own time scale for the development of the breeder, it seems evident that it cannot possibly become "mature," in the sense of producing power at a stable price--that is, constant with time--before 2040. (As to fusion, since there is no evidence as yet that the basic physical process actually works, one can reasonably conclude that this technology will reach maturity well after that date--if ever.)

That the breeder program is incapable of relieving the drain on natural fissionable energy resources--and therefore the rise in the price of electricity inherent in the development of the present nuclear power program--is also evident from ERDA's time scale for the introduction of the breeder. Figure 6, which is based on data provided in the Environmental Impact Statement for the breeder program, shows the effect of the breeder program, as projected by ERDA, on the projected demand for fissionable fuel needed for the entire nuclear power program. It is clear that the breeder cannot be expected to relieve the demand for natural fissionable material until approximately 2040--if all of ERDA's optimistic technical expectations are, in fact, met. Thus the nuclear power program would need to rely on increasingly expensive natural fuel until then. This means that even ignoring the problem of achieving an economically "mature" breeder-construction industry--which, according to

ERDA projections would need to build from 1200 to 3000 breeder reactors (the exact number depends on the breeding ratio) in order to support about 600 LWR's--there is no hope that the nuclear power program could halt the rise in energy costs until at least 65 years from now.

In sum, the ERDA effort in support of nuclear power, the breeder program, coal conversion, and shale oil production, which represents \$2,242 million of the total of \$3445 million of non-military research and development expenditure (or about 65 percent) could not possibly achieve the essential goal of a national energy program--to establish an energy system capable of meeting national needs, on a continuous basis, at stable prices--in less than 60-75 years. In my opinion, continuously rising energy prices would place an unacceptable stress on the economy, and on the people of the U.S. whom the economy is intended to support, long before that time.

Some Features of an Alternate Plan

The only possible means of achieving a system of energy production at stable prices is solar energy--which represents 3.4 percent of the ERDA non-military research and development budget. Sunlight is the only form of energy in which both requirements for a stable energy price can be met at the present time. These requirements are that the source of energy is unlimited and therefore not subject to the constantly rising price imposed by the law of diminishing returns, and that the

energy-transforming technology is sufficiently "mature" that its costs remain stable over time.

In contrast with nuclear technology, many solar technologies have been sufficiently tested to detect unexpected problems. They can therefore be considered "mature," and not subject to the increased costs required to solve unexpected technical problems. And since no solar devices have been mass-produced as yet, their prices are likely to fall when this occurs.

One important solar technology--space heat and hot water--is now ready, economically, for immediate application. As shown by an analysis by the Center for the Biology of Natural Systems (Appendix II), mixed solar-conventional systems can now already reduce the householder's costs for space heat and hot water in many parts of the country. This technology can now be regarded as mature and therefore capable of providing energy for space heat and hot water at a stable, competitive price, which could fall further if applied on a sufficiently large scale to encourage mass-production.

Another important example is the solar photovoltaic cell, which generates electricity directly from sunlight. Originally developed to power space satellites at a cost of about \$200 per watt, in 1973 photovoltaic cell arrays for terrestrial use sold for \$50 per watt (peak) and in 1976 are available for \$12-14 per watt (peak). While this price is

still far too high to permit generation of electricity at a competitive cost, it is falling and can only be expected to fall further. Indeed, the most extensive analysis of this technology, made by Solar Subpanel IX of the task force that prepared the report to the President on "The Nation's Energy Future" in 1973, predicted that the cost of photovoltaic cells could be reduced to \$0.30 per watt and that the "...achievement of the cost goals of this program will result in the production of economically competitive electric power by the year 1990."

Wind energy conversion is another relatively "mature" solar technology. Numerous European countries have had moderate wind power programs for many years, and the technology is well understood. The Central Vermont Public Service Corporation ran a 1.25 megawatt wind turbine for a time in the early 1940's. It was not quite economical to run, but the designers estimated that design improvements could be expected to lower its cost sufficiently to become economical. As a result, as shown in Figure 7, cost forecasts predict a downward trend in the price of wind-generated electricity.

Ocean thermal energy conversion systems and solar thermal electric systems are probably the least mature solar technologies. While it is unquestionable that they will work, the first few years of large-scale testing might reveal unforeseen design problems that could increase the associated costs. Nonetheless, even these relatively complex (as compared to

other solar energy technologies) they are far simpler and inherently less subject to unexpected, costly technical difficulties than the coal conversion, shale oil, and nuclear technologies that are emphasized in the ERDA Plan.

In actual practice, the ability of solar technologies to achieve stable energy prices within a reasonable time will depend not only on their maturity, but also on their absolute costs relative to energy output. Only if a solar technology's absolute cost is equal to or less than the technology which it is to replace will the change take place without a concurrent rise in price. This means that the introduction of solar technologies into the national energy system will need to be timed to coincide with the expected time at which their costs become economically competitive. These crossover times of the relative costs of the alternative technologies will vary with the complexity and degree of development of the solar technology, and with the rate of increase in the price of energy produced by conventional technologies.

As indicated earlier, solar space heat and hot water are already competitive in some parts of the country, and soon will be so almost everywhere, providing they are introduced as part of a mixed solar/conventional system. Accordingly, it would be possible to apply these technologies immediately as the first step in the task of slowing, and eventually stabilizing, the present sharply rising price of energy. Since these uses of

energy represent 15-20 percent of the national energy budget, such an immediate program for large-scale utilization of solar energy would have an appreciable impact, especially on the heating costs which now so greatly trouble householders. As the price of conventional energy continues to increase, it will become economical to expand the solar systems, until they take over the entire heating load. The cost should thereafter become constant.

A recent development promises to extend solar technology, on economically competitive terms, into the area of domestic and commercial supply of electricity. This device, as described by the developers, Robert I. Frank and Roy Kaplow, of MIT, is based on concentrating sunlight on a relatively small photovoltaic cell which, operating at high light levels, can yield a proportionally greater intensity of electric power--providing it is cooled. This is accomplished by circulating water around the cell; the water becomes hot enough to serve as an effective source of space heat and hot water. According to the developers, a unit costing about \$5,000 is expected to provide about 80 percent of the space heat and hot water requirements of an average home in regions from Washington State south and about 350 kilowatt-hours of electricity per month (average domestic consumption is 660 kilowatt-hours per month). They expect a pay-back time of ten years or less for such units. If this device performs as expected, a large part of the energy needs represented by space heat, hot water and residential and

commercial power--amounting to about 34 percent of the national energy budget--could be met at costs sufficiently low and constant to contribute significantly to the stabilization of the price of energy.

The absolute costs of other solar technologies are not yet sufficiently well known to estimate when they could be economically introduced. However, if the ERDA plan were designed to make full use of the inherent advantages of solar technologies it would include urgent studies designed precisely to produce this missing information, for example, by expediting the construction of pilot plants. The vanishingly small support given to solar research and development in the present ERDA plan makes this impossible. Indeed, also lacking in the ERDA plan are sufficient field studies to determine how to expedite the applicability of existing, economically competitive solar technologies, such as the combined heat and power device described above (which, incidentally, appears to have been developed without any support from ERDA or any other government agency).

The properties of the various possible energy sources and technologies, as they relate to the two requirements--an unlimited source and a "mature" technology--which are together essential to the production of energy at a stable price, are summarized in Table II. Several energy technologies are already sufficiently affected by the law of diminishing returns as to be

totally incapable of ever contributing to energy price stabilization: combustion of oil and natural gas and the production of electricity by present (LWR) nuclear reactors. Since the estimated domestic reserves of oil shale (about 1,200 quads) are less than the total recoverable reserves of oil (1,876-2,363 quads, including "subeconomic" reserves) oil shale will be as much affected by diminishing returns once it is exploited and therefore, like oil and gas, can never contribute to energy price stabilization. Reserves of coal are so large and laterally dispersed that production costs may remain free of the effect of diminishing returns for some time--perhaps 100 or more years. Therefore, if used for direct combustion (as in coal-fired power plants), which is a mature technology, coal can for the time being contribute to the stabilization of energy prices.

The remaining technologies listed in Table II--fusion, the breeder reactor, and various solar technologies--are all based on essentially inexhaustible energy resources (assuming, charitably, that fusion is feasible, and that breeder reactors can actually be made to "breed" sufficiently to extend fossil fuel reserves for some hundreds of years). These technologies are therefore not subject to diminishing returns and are capable of contributing to energy price stabilization--whenever the necessary energy transformation technology becomes sufficiently mature and economical to become stable and competitive in cost.

For reasons already discussed the breeder and fusion cannot possibly reach this point before 2040 or 2050. Two solar technologies--biomass conversion (which is already used on a small scale in many places) and solar heat (probably including as well the new solar heat/power technology)--are now sufficiently mature and economical to support immediate introduction as energy price stabilizers. The remaining solar technologies are at various stages of maturation, but could be introduced and contribute to energy price stabilization in the period 1980-1990.

In sum, it is possible, beginning at once, to slow down the present escalation of energy prices and to move toward stabilization by (a) relying on coal-fired power production in the near- and mid-term, and (b) introducing the various solar technologies as they mature, beginning with solar heat and heat/power installations. Allowing for the uncertainties involved in converting solar electricity to essential liquid fuels (through the use of hydrogen either directly, or after conversion to a hydrocarbon), it should be possible to gradually approach approximate energy price stabilization over the next 20-25 years-- a period which is, in any case, the minimum time in which all the huge productive enterprises could be completed.

Clearly, in any plan that is designed to solve the nation's energy problems, as they have been defined above, the highest priority should be given to the perfection and

application of solar technologies and coal production and combustion. In the ERDA Plan these priorities are exactly reversed. Nearly all of the research and development support is assigned to technologies for nuclear power production, coal conversion and shale oil. Solar technologies receive only 4.4 percent and coal combustion technologies only 1.5 percent of the research and development support.

Conservation

I have thus far considered only one side of the energy problem--the task of producing energy in ways that can begin to reverse the present, potentially disastrous trend toward ever-increasing energy prices. Clearly, the other side of the problem--the use of energy--is also involved in this task. Even if, as indicated above, temporary reliance on coal-fired power and the step-by-step introduction of solar technologies, as they mature and become economically competitive achieves energy price stabilization, it would still be important to reduce to a minimum the overall investment of capital that will be required to build these new power sources. This places a considerable premium on energy conservation--that is improvement in the efficiency with which energy is used to produce goods and services.

How well does the ERDA Plan reflect the possibilities for energy conservation? According to the Executive Summary of the ERDA Plan,

"Conservation (energy efficiency) technologies are singled out for increased attention and are now ranked with several supply technologies as being of the highest priority for national action" (p. 1).

While this statement is a welcome advance over the gross neglect of energy conservation in the previous Plan, its practical effect is questionable since the proposed expenditures for conservation represent only \$91 million, or 2.6 percent of the total non-military budget. What is even more serious is that nowhere in the very extensive documents of the Plan is there any mention of a study that shed startling new light on the problem of energy conservation that was completed by a task force of the American Physical Society in the summer of 1974. Prior to the APS study every comprehensive (that is, involving the entire production system rather than single industrial operations) analysis of the efficiency with which energy is used was based on the First Law of Thermodynamics. Since this law states that energy can be neither created or destroyed--or, that it is always conserved--its applicability as a measure of energy conservation is obviously limited. Indeed, as pointed out by the APS study, while energy is always conserved, the property of energy that gives it its value--the ability to do useful work--is not conserved, but is always lost whenever energy is used to produce work. This is the realm of the Second Law of Thermodynamics, which describes the efficiency with which work can be obtained from energy under different circumstances.

To appreciate the contrast between these two approaches I might note that the efficiency of a conventional oil-burning furnace is about 65-75 percent when computed according to the First Law, but only about 8 percent when computed by the Second Law. Thus, the First Law computation would suggest that only a small improvement in efficiency could be made in this instance, whereas the Second Law computation shows that the actual thermodynamic efficiency could be improved about 9-fold--that is the amount of work required to accomplish the task could be reduced by about 90 percent. The overall Second Law efficiency of the use of energy in the U.S. is probably no more than 15 percent--leaving much more room for improvement than would be indicated by conventional, First Law analyses. It is astonishing to discover, from a careful reading of the ERDA Plan, that there is not a single reference to the momentous implications of the APS analysis, nor any evidence in the proposed scheme of research and development that these have been appreciated.

ERDA and Science

I believe that the failure of ERDA to act on the enormously important leads provided by the APS study toward the development of a rational energy conservation program is symptomatic of a more general failing on the part of the agency: that ERDA's contacts with the independent scientific community are relatively weak. Additional evidence which tends to support this view is the following.

Although nuclear chemists were convinced some years ago that low-energy accelerators would enable wholly new types of elemental analyses that could contribute significantly to both basic and applied research (such as analysis of environmental samples) ERDA withdrew support from university accelerators of this type. Fortunately, with some aid from the National Science Foundation, and considerable entrepreneurial effort by university researchers, many of these accelerators have been kept in operation. Their importance has now become apparent not only in environmental analyses, but ironically--in view of the ERDA conviction that low energy accelerators were no longer at the frontier of scientific research--also in their unique role in research which is certainly at the frontier of science: evidence for the existence of a group of hitherto undetected "superheavy" elements recently reported by R. V. Gentry, Science, 169, 670 (1970).

Another example is the complete absence, in ERDA's proposals for the development of synthetic fuels and shale oil, of the considerable evidence in the scientific literature of the occurrence of carcinogenic substances in these fuels. Undue isolation from the scientific community probably accounts, as well, for ERDA's failure to pay adequate attention to the role of energy in agriculture. As far as I can ascertain the present ERDA staff includes no more than one or two specialists qualified in agriculture, although agricultural production now accounts for

as much energy consumption as the petroleum industry, and has become very vulnerable to energy problems, as recently reported at a conference on this problem held at CBNS, with the support of the National Science Foundation/RANN.

Separately, such inadequacies might be regarded as minor, in view of the huge size of the whole ERDA program. However, in so complex an enterprise the failure adequately to appreciate a single scientific point can have far-reaching, and often unfortunate consequences. Perhaps the most important example is contained in a fundamental scientific datum, on which the entire strategy of the ERDA Plan seems to have been based--the amounts of energy available from different domestic resources.

ERDA's summary of these data is published as Table VI-2 in Volume I of the 1976 Plan. According to this table, the smallest recoverable energy resources are those of natural gas and petroleum, estimated at 950 quads each, as compared with 1,800 quads for uranium and 21,400 quads for coal. The reference given for the oil and gas estimates is a report (No. 725) of the U.S. Geological Survey, "Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States, 1975". This report does indeed include the figures cited in the ERDA table. However, the report also states that these estimates are based on the economic conditions that prevailed in the oil industry as of 1974. In particular, it

becomes clear from a detailed reading of the report that the foregoing estimate is based on the then current rate of recovery of "oil in place"--that is the proportion of the underground oil that is actually recovered. This is now an average of about 32 percent. It is also evident from the report that the magnitude of the recovery rate is determined by economic considerations--specifically the amount of additional investment in expensive secondary and tertiary recovery methods that is warranted at current oil prices. Thus, as pointed out in a recent report on oil recovery by the National Petroleum Institute ("Seminar on Reserves and Production Capacity", April, 1975) there are methods available that are capable of recovering as much as 60 percent of the oil in place, but these are expected to be used only when warranted by an increased price of oil. Recognizing this basic fact, the USGS report includes in its estimate of recoverable oil reserves 926 to 1,413 quads of "subeconomic reserves"--that is oil that is physically recoverable, but economically so only at higher oil prices than at present.

Accordingly, the actual amount of physically recoverable domestic oil reserves is not 950 quads as reported in the ERDA table, but 1,876-2,363 quads, making it the third largest reserve, just ahead of uranium. (Similarly, with "subeconomic reserves" added, the domestic natural gas reserves are not 950 quads but as much as 1,330 quads.) The far-reaching consequence

of this erroneous evaluation of the actual oil and natural gas reserves is evident from the fact that the total oil reserves available at the 60 percent recovery rate would be sufficient to meet all domestic demand, at the current rate of consumption, for a period of 50-60 years (but, as noted earlier, at a rapidly rising price). In other words, the actual size of the reserves suggests that the energy problem which appears to provide the basic motivation for the ERDA Plan--that we now import about 40 percent of our needed petroleum--is not a physical problem but an economic one.

Indeed, as can be seen from the main burden of my comments on the ERDA Plan, its chief and most damaging defect is the general failure to appreciate the importance of the relation between the energy sources and technologies and energy economics. Although responsible for a crucial and exceedingly complex area of science and technology--which is inextricably related to fundamental economic processes--ERDA seems to have relied for its basic analyses not on independent scientific assessments, but more on the conventional wisdom, particularly as expressed in the Presidential energy messages, that we are physically "running out" of present domestic energy sources and that new ones need to be physically created.

However, the continued depletion of the nonrenewable energy resources on which we now rely is expressed in an economic dimension, the rising price of energy. As a result we

cannot effectively respond to the inevitable physical depletion of domestic nonrenewable sources of energy simply in terms of "technology development"--which is the basis of the ERDA Plan. Rather, what is required is a response that evaluates the alternative ways of producing and using energy in terms of their economic effects on the national welfare.

Conclusions

It is evident, both from the ERDA Plan and from my criticism of it, that the nation confronts a huge and difficult problem of negotiating the transition from our present pattern of energy production and use to one which can provide an adequate, environmentally acceptable, supply of energy at a stable price. Otherwise, we will be faced with escalating inflation, massive obsolescence of capital goods and the serious economic disruption--rising prices, unemployment, dislocation of regional economics--that will inevitably follow in their wake.

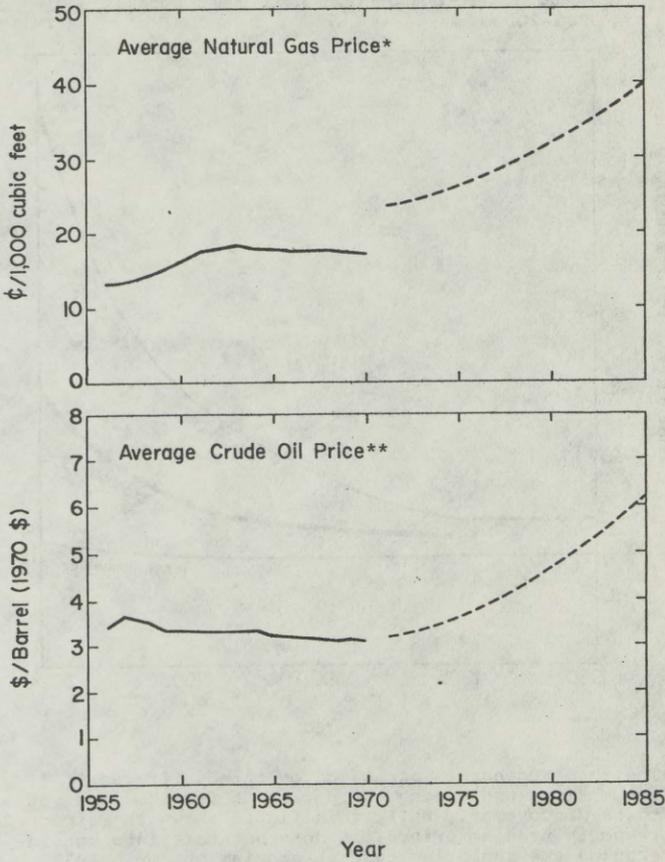
Even if we do adopt such a national energy policy, there will nevertheless need to be certain large-scale changes in the production system, such as curtailment of the production of energy-intensive synthetic materials for which natural replacements are available. However, if such changes are arbitrarily forced upon us by the constantly rising price of energy it will be very difficult to achieve them in an orderly way that could minimize economic disruption and personal hardships. If energy prices are stabilized by an intensive program to develop solar energy, there is some hope of making this historic passage at minimum economic and social cost.

In any case the passage will be a very difficult and dangerous one. But if the most dangerous and disruptive force involved--the accelerating price of energy--is ignored, the difficulties will be enormously magnified. This, I believe, is the most serious fault with the ERDA Plan. It is a product of a blind devotion to technology; of a blind denial of the economic factors that determine what technology can actually accomplish for the nation's welfare.

Clearly, a sweeping change in the precepts and priorities which govern the present ERDA Plan is necessary if the nation is to have a rational effective energy policy. But this cannot be carried by ERDA alone. The largest part of the plan--the development of the breeder--is mandated by previous legislative action, and will need to be changed by similar action. Nevertheless, I believe that it is ERDA's responsibility--with, I would hope, the cooperation of the scientific community--to provide the Congress with an objective analysis of the nation's energy problem--its interrelated scientific, technological and economic features--so that the issues are clearly and decisively drawn. It will then be the responsibility of the Congress to mandate the crucial steps that must be taken to assure for the nation a system of producing and using energy that can truly serve the welfare of the people.

* * *

Figure 1A

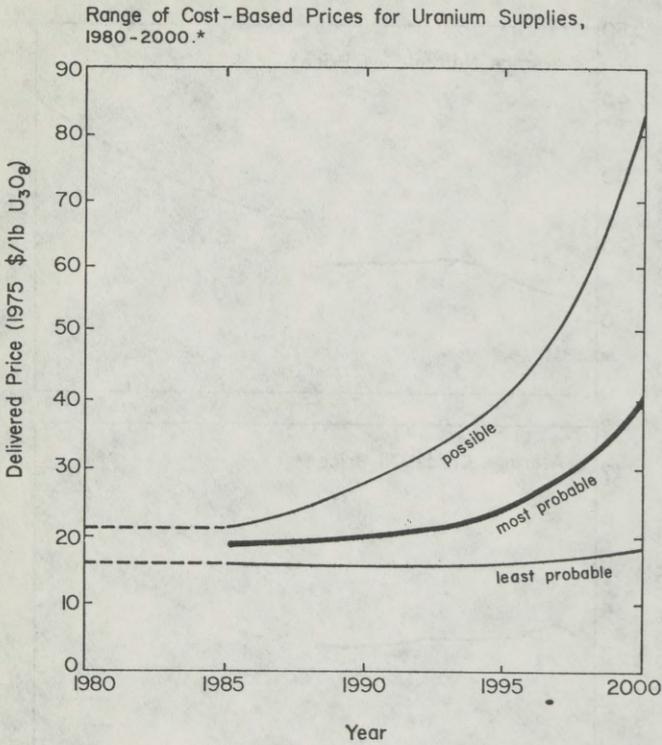


*Projections are for a 15% return on net fixed assets and a 16% increase in production rate, 1975 to 1985.

**Projections are for a 15% return on net fixed assets and a 36% increase in production rate, 1975 to 1985.

Source: U.S. Energy Outlook, Oil and Gas Availability, National Petroleum Council, Washington, D.C., 1973.

Figure 1B

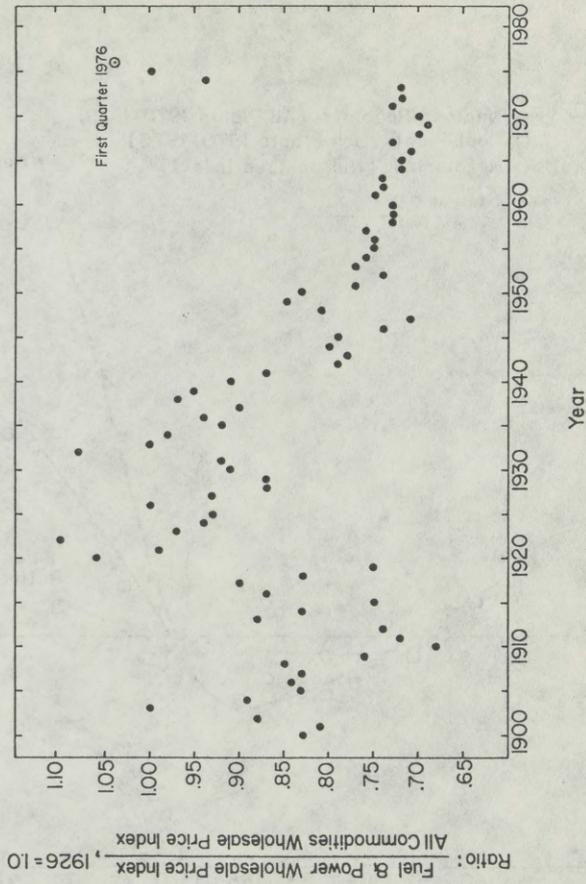


*The three scenarios are based on three different assumptions concerning the purity of uranium ores yet to be discovered. While this figure shows the expected trend in uranium prices, it does not take into consideration the rapid increase in uranium price in 1975, when the price rose to over \$40 per pound.

Source: Nuclear Fuels Supply, Edison Electric Institute, New York, 1976.

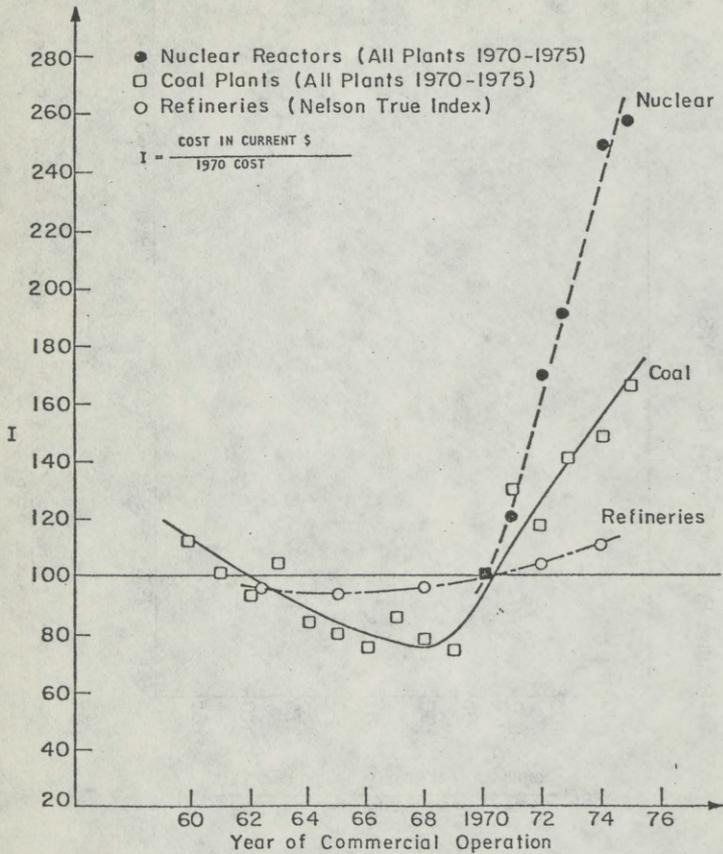
Figure 2

Relative Price of Energy, 1900-1976.



Source: Survey of Current Business, Department of Commerce, Washington, D.C., various years.

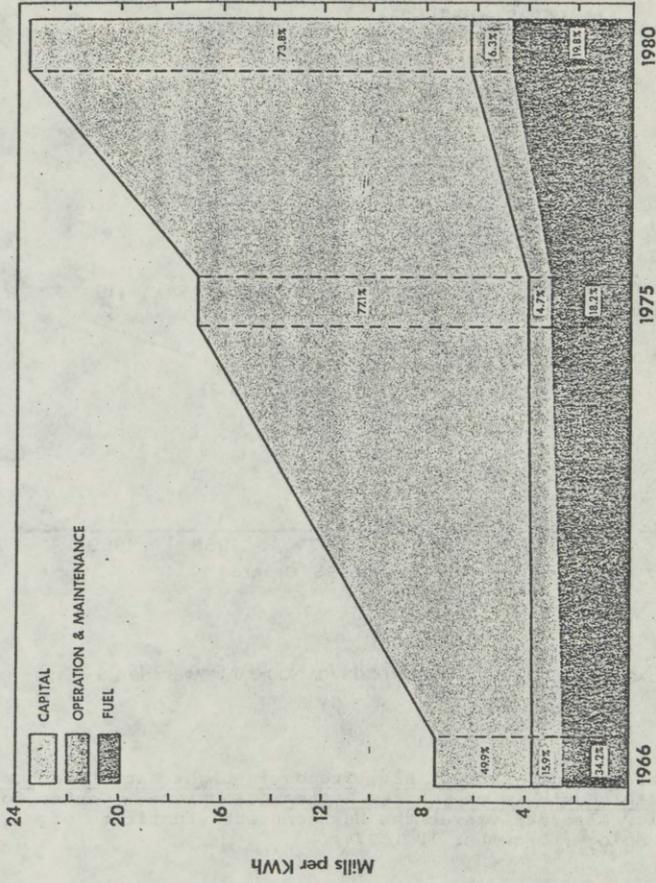
Figure 3



Cost Index Trend for Nuclear Plants, Coal Plants,
 and Refineries

Source: I. C. Bupp et al., Trends in Light Water Reactor Capital Costs in the United States (Cambridge: Center for Policy Alternatives at the Massachusetts Institute of Technology; December 18, 1974).

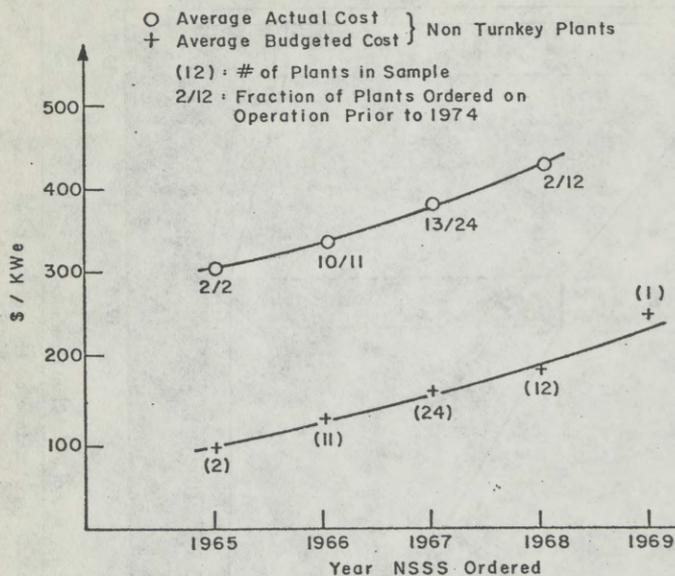
Figure 4
HISTORICAL TRENDS IN THE COST OF NUCLEAR POWER GENERATION



Year of Initial Plant Operation

Source: R. E. Scott, "Projections of the Cost of Generating Electricity in Nuclear and Coal Fired Power Plants" (St. Louis: Center for the Biology of Natural Systems, Washington University; December 1975).

Figure 5

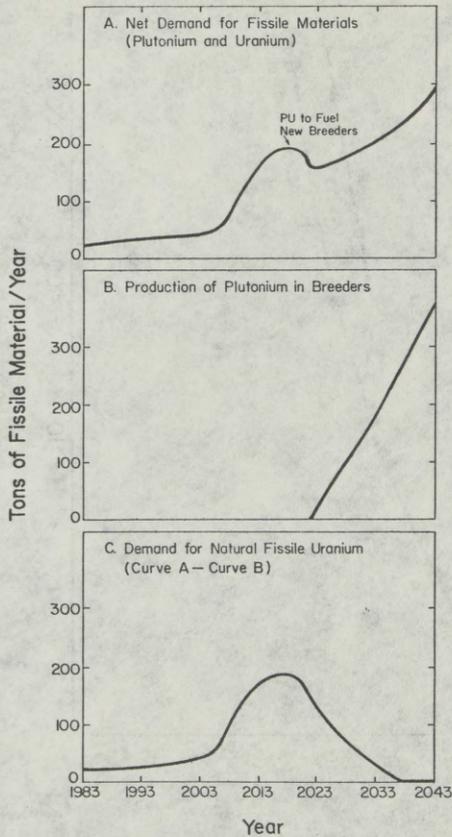


Expected and Actual Cost Trends for Nuclear Power Plants

Source: I. C. Bupp et al., Trends in Light Water Reactor Capital Costs in the United States (Cambridge: Center for Policy Alternatives at the Massachusetts Institute of Technology; December 18, 1974).

Figure 6

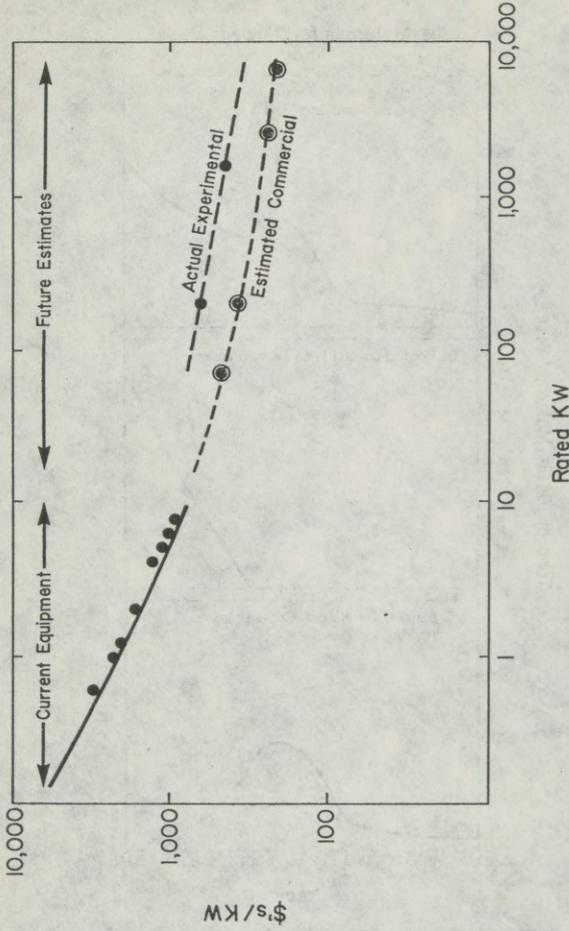
Fissile Materials for Nuclear Power



*The breeder environmental impact statement assumed that the first commercial breeder would not begin production until 1987. It is now evident that the breeder will not be commercialized until 2000. Therefore, our calculations simply shift the fuel supply curves 13 years out.

Source: Proposed Final Environmental Impact Statement for the Liquid Metal Fast Breeder Reactor, Atomic Energy Commission, 1974.

Figure 7
The Selling Price of Wind Turbines (1973 \$).



Source: Project Independence Solar Energy Task Force Report, Federal Energy Administration, Washington, D.C., 1974.

TABLE I
Capital Productivity of Alternative Energy Sources

Energy Source	Capital Productivity (BTU's per year per dollar of capital invested)
Crude Oil Production ¹	
1974 (actual)	16,800,000
1988 (projected)	4,480,000
Coal (strip mined) ²	2,000,000
Shale oil production ³	420,000
Synthetic fuel from coal (liquid)	254,000
Coal gasification ³	160,000
Coal-fired electricity generation (\$800/kw) ⁴	28,683
Nuclear electricity generation (\$1,000/kw) ⁴	22,423

¹The capital productivity of oil production was derived from information in Oil: Possible Levels of Future Production, Final Task Force Report, Project Independence, FEA (Washington, D.C., November, 1974), pp. IV-2 and IV-21.

²The capital investment required to produce one ton of coal was obtained from U.S. Energy Outlook: Coal Availability (Washington, D.C.: National Petroleum Council; 1973), p. 38.

³The capital investment required to produce different synthetic fuels was obtained from the Project Independence Task Force Report on Synthetic Fuels from Coal, p. 35, and also the Task Force Report on Oil Shale, p. 65. FEA, U.S. Dept. of the Interior, Washington, D.C.: U.S. Government Printing Office; November, 1974.

⁴The estimates for coal-fired and nuclear power plants are for base load power generation, operating at 75% of capacity for 1 year.

Table II

ECONOMIC CHARACTERISTICS OF MAJOR ENERGY TECHNOLOGIES

Technology	Availability of basic fuel	Maturity of the technology*	First possible date at which technology can contribute to stabilization of overall energy prices**
Present nuclear reactors (LWR)	diminishing	immature	never
Oil and natural gas combustion	diminishing	mature	never
Shale oil conversion	diminishing	immature	never
Coal			
- direct combustion	gradually diminishing	mature	now, but not long-term
- conversion		immature	uncertain, but not long-term
Fusion	inexhaustible	immature	after 2050
Breeder reactor	inexhaustible	immature	2040
Direct thermal solar technologies, i.e. heating and cooling	inexhaustible	mature	now and long-term
Wind energy conversion	inexhaustible	mature	1980
Photovoltaic electric power production	inexhaustible	mature	1990
Solar thermal energy conversion (to electricity)	inexhaustible	not fully mature	1990
Ocean thermal energy conversion (to electricity)	inexhaustible	not fully mature	1985
Biomass conversion	inexhaustible	mature	now and long-term
<u>Solar technology, overall</u>	inexhaustible	a mixture of mature and rapidly maturing	generally by about 1990***

*Maturation signifies that the cost of technology has become constant or declining.

**In order for a technology to stabilize prices it must depend on a fuel which is essentially inexhaustible and it must be mature. The time given is an estimate of the date at which the technology is mature, and is producing a significant amount of energy.

***Solar impact dates are "projected dates of economically competitive operation" taken from the AEC Subpanel IX report and given in Testimony of the Scientists' Institute for Public Information in Regard to the AEC's Draft Environmental Statement on the Liquid Metal Fast Breeder Reactor, April 25, 1974 (Scientists' Institute for Public Information, New York).

Appendices

I: R.E. Scott, Projections of the Cost of Generating Electricity in Nuclear and Coal Fired Power Plants (St. Louis: Center for the Biology of Natural Systems, Washington University; December 1975).*

II: A. Shams and R. Fichtenbaum, The Feasibility of Solar House Heating: A Study in Applied Economics (St. Louis: Center for the Biology of Natural Systems, Washington University; April 1976).*

*Copies of these reports may be obtained from the Center for the Biology of Natural Systems, box 1126, Washington University, St. Louis, MO 63130.

Senator BUMPERS. Our third witness this morning is Dr. Richard Dowd of the Congressional Budget Office.

STATEMENT OF DR. RICHARD DOWD, CONGRESSIONAL BUDGET OFFICE; ACCOMPANIED BY KENDRICK WENTZEL, CONGRESSIONAL BUDGET OFFICE, AND NICOLAI TIMENES, JR., DEPUTY ASSISTANT DIRECTOR, CONGRESSIONAL BUDGET OFFICE

Dr. Dowd. Thank you very much. That is a hard act to follow. I feel like Olga Korbut following Nadia Comaneci.

Mr. Chairman, I appreciate the opportunity to testify on the subject of energy research and development and the administration's national plan.

I am accompanied by my colleague, Kendrick Wentzel, and Nicolai Timenes, Jr., Deputy Assistant Director of CBO, who is here with us.

At the request of the House and Senate Budget Committees, the Congressional Budget Office undertook an analysis of energy research, development, and demonstration strategies. This analysis is reported in a CBO background paper entitled, "Energy Research: Alternative Strategies for Development of New Energy Technologies and Their Implications for the Federal Budget." The paper, which is the basis for my testimony, has been published, and we are happy to provide copies for the record.

I would like to take this opportunity to thank the staff of this committee, especially Dr. Dan Dreyfus, for providing many helpful comments on an earlier draft.

It is the statutory responsibility of CBO to provide nonpartisan analysis of policy options; hence the report makes no recommendations, and I will make none today. I would like, however, to offer a perspective on the design of alternative strategies for research, development, and demonstration (R.D. & D.).

The Congress has long been concerned with energy issues; in recent years that concern has increased markedly, paralleling an increasing national awareness of energy problems.

Recognizing the important contribution that research can make to the solution of both short- and long-range energy problems, Congress has expanded and redirected Federal policies and programs in energy research, development, and demonstration. It has directed the Energy Research and Development Administration (ERDA) to design a national energy research and development plan and a program for implementing it.

In response to such changing priorities, ERDA in its national plan has described varying potential energy futures for the United States; other groups have also formulated alternative futures.

While the U.S. energy future could take any of these shapes, a consensus seems to exist that the most desirable future would have at least three characteristics: One, a reasonable balance between total demand and domestic supply, resulting in reduced dependence on imports; two, minimal adverse environmental impacts; and, three, a phase transition from the dominance of oil and gas from traditional sources to a much greater role for a broad variety of new technologies.

The consensus does not yet extend to a specific balance among objectives or among means of achieving them. Indeed, much of the current

energy debate focuses on just such issues: For example, the tradeoffs between increased energy supply and environmental quality, between the need to develop domestic resources and minimizing cost to consumer or taxpayer, between long-run economic efficiency and short-term impact on inflation and employment and between increased imports and even rapid depletion of domestic resources.

To achieve such a future, the United States would have to rely heavily on: One, conservation or demand management; two, important contributions from all major near-term technologies; and, three, reliance, in the long run, on some sort of "ultimate" technology using a virtually inexhaustible source. ERDA and others have postulated a wide variety of scenarios.

While there is little consensus on which would be best or most likely, it is clear that there are no lasting "pure" solutions, and that the problem of finding an acceptable future is one of balancing conflicting objectives, of using a variety of technologies and policy instruments, and, especially, of managing the transition, over the next several decades, from current reliance on new sources of oil and gas to traditional sources to new levels and mixes of energy development and use.

The impediments—technical, environmental, economic, or institutional—to implementation of new or expanded technologies are of two types: Those due to uncertainties, for example, technical feasibility and those due to other factors, for example, prohibitive costs. A strategy for R.D. & D. can be designed to gather information that can reduce uncertainties. Such a strategy can also help develop methods to overcome other impediments, should this be judged desirable. However, other mechanisms, such as financial incentives, may be more appropriate in certain instances.

The criteria for designing research strategies may be grouped into three categories: Support of desirable futures, insurance against failure, and cost.

The first criteria, the degree to which a given research strategy supports desirable futures depends on: Its consistency with congressional mandates emphasizing energy conservation, renewable resources, and environmental technologies; its support for an energy future not limited to a few sources but drawing from a wide diversity of types; and the balance it achieves among technologies that could provide energy over three timeframes—near, mid, and long term.

The second criteria, providing insurance against failure minimizes the chance that all or many technologies will prove infeasible, as some surely must.

The degree to which a strategy satisfies this criterion depends on—its adequacy of attention to basic, as distinct from applied, research; the pursuit of diverse technical approaches to any one source, for example, supporting both centralized and localized conversion of solar energy, so that technical risks are hedged; balance in the scale of research, so that large, costly demonstration projects do not crowd out earlier stages; and proper pacing, so that the program does not proceed so quickly that problems raised in one stage are incorporated into the next.

Finally, cost is a criterion because Federal financial support for any endeavor must generally be limited. Cost could therefore become the

determining factor in choosing between alternative strategies where other considerations were equal or similar.

To illustrate the application of these criteria, five potential alternative research strategies have been evaluated. Each strategy differs in the degree to which it satisfies the criteria.

The five strategies are:

One, a strategy of continuing ERDA's present programs, completing ongoing projects and allowing modest real growth, but not allowing major new starts. This is referred to as the "base program completion" strategy.

Two, a "full funding" strategy, including the elements of the base program completion strategy and carrying out all major additional R.D. & D. projects identified in ERDA's national plan.

Three, a strategy emphasizing long-term nuclear fission technologies and downplaying all others.

Four, a strategy downplaying the fission programs, but emphasizing all other long-term technologies.

Five, a strategy emphasizing near- and mid-term technologies and deferring all major long-term technology demonstration projects not already underway.

The base program completion strategy used the President's fiscal 1977 budget request, with its 5-year projections, as a base. Modest growth rates were incorporated and completion of projects already begun was assumed. However, no new projects would be initiated beyond 1977; it is very close to a "no new starts" strategy.

Consistency of this strategy with desirable future is impaired by its reliance upon past projects and priorities. It would not respond to recently articulated priorities in solar energy, conservation, and environmental protection, now would it permit pursuit of diverse technical approaches within any one source. While its pace of development would not be excessive, its lack of diversity would not provide insurance against the likelihood of future failures. This strategy would total \$40.5 billion in budget authority over the next decade; it would reach its 1-year peak of \$4.7 billion in 1986.

The full funding strategy would add to the base programs completion strategy all of the demonstration projects identified in ERDA's national plan in all program areas. This strategy could be consistent with a desired energy future, including ERDA's preferred future, in that all program areas would be supported, providing diversity within each source and across all timeframes. Its weakness stems from the scale of effort and the pace. So much of its effort is devoted to large demonstration projects that budget constraints could imperil initiatives in the vital predemonstration stages of research and development. The full funding strategy would cost \$63.7 billion in budget authority over the next decade; its 1-year peak of \$7.9 billion would occur in 1984.

Between the two funding extremes represented by these strategies, we have formulated three different strategies, representing similar aggregate funding, but different program emphasis.

The fission strategy would emphasize long-term solutions, especially the nuclear breeder reactor. It would add to the base program completion level all the demonstrations in nuclear fission programs, but would not include demonstrations of other technologies.

This neglect of important nonfission sources, conservation, and the environment would be inconsistent with ERDA's desired future. It might not insure against failure, because it focuses only on one technology, even though all time frames are covered. Pacing might also be a problem, because of its heavy emphasis on a single technology. This strategy would cost \$51.3 billion in budget authority; its 1-year peak of \$6.1 billion would occur in 1981.

The fourth strategy would also emphasize long-term solutions; it would rely on nonfission technologies. It would add to the base program completion all of ERDA's suggested nonfission demonstrations, particularly for nuclear fusion and solar sources, but would not include new demonstrations for nuclear fission.

This strategy would also be inconsistent with ERDA's desired future because it would not assign an important role to the breeder. However, its support for a wide diversity of sources, other than the breeder, would help insure against failure. This strategy would cost \$51.6 billion in budget authority; its 1-year peak of \$6.7 billion would occur in 1984.

The fifth strategy would emphasize near- and midterm technologies. It would include all components of the base program completion strategy, to which would be added those projects identified in ERDA's national plan from which results could possibly be implemented in the near or midterm.

This strategy would not be completely consistent with desired futures because demonstration projects for long term technologies would be deferred. However, support of long-term processes at pre-demonstration levels would preserve some diversity among sources, including conservation and renewable resources. This strategy would cost \$48 billion in budget authority in the next decade; its 1-year peak of \$5.4 billion would occur in 1983.

The total costs for these strategies over the next decade range from over \$40 billion for completion of the base program to nearly \$64 billion for the full funding strategy. The budget impacts of each strategy are summarized in table I, which appears on page 10 of my prepared testimony. Those are all in constant 1977 dollars.

Each of the strategies implies future budget authority significantly higher than current levels. The President's fiscal 1977 budget authority request for energy R.D. & D. is \$3.1 billion. While a strategy with a budget lower than current levels could certainly be designed, it would require a major shift in priorities set by Congress since the energy crisis of 1973-74.

The chart, which appears on page 14 of my prepared testimony, shows the budget authority pattern required for such strategy over the next 10 years. With the exception of the base program completion strategy, for which funding increases slowly, the budget authority required for each strategy rises to a maximum and then declines. Because the major projects now planned cannot extend a research program indefinitely, actual budgets after 1980 would depend on intervening decisions about budget levels, on the desirability of planned projects, and on cost requirements for introduction of new projects.

The desirability of each of these alternative strategies depends in part on a judgment as to which potential energy future is most satisfactory for the United States. If funding constraints are extremely

severe or if it is decided that future large-scale demonstrations should be primarily the responsibility of the private sector, then it would be appropriate to select a strategy such as the base program completion strategy.

If, at the other extreme, Congress decides that extensive Federal support of demonstrations is appropriate and that an additional \$23 billion, beyond the costs of completing the base program, should be made available, then a full funding strategy could be selected.

Selection of one of the three middle-cost strategies, which have very similar budget implications, could result from a decision that some intermediate level of funding should be supported. Such a selection could also reflect a congressional decision that, for budgetary or other reasons, only one of the three major groups of middle-cost demonstration initiatives—near and midterm, fission, or nonfission technologies—deserves support.

The five strategies imply quite different mixes of fission and non-fission research during the decade. The range is from about \$25 billion—with nearly half of all funding devoted to fission in that strategy—to about \$13 billion, or a quarter of all funding, in the strategy emphasizing nonfission technologies.

The influence of demonstration stages is also quite significant in the choice of strategies. As funding for demonstration projects grows, the total R.D. & D. program becomes less flexible. The full funding strategy would devote about 45 percent of all funding over the next decade to demonstration projects, while the strategies emphasizing fission, nonfission, or near and midterm technologies would spend about one-fourth of the total on demonstrations, and the base program completion strategy would spend about one-tenth on demonstrations.

Final detailed decisions on a research strategy do not have to be made now. The budget paths described above would result from a series of decisions to be made over the next decade. Research is dynamic, and new information becomes available almost daily. That information is useful in itself; it can also be used to help shape those decisions to be made in the future.

Each such decision, however, represents a step along a strategic path. The pattern of those decisions over the next few years, especially with respect to funding major demonstrations, will—whether by conscious design or by piecemeal actions—result in the definition of a U.S. energy R.D. & D. strategy. That pattern of decisions will have significant impacts on the Federal budget over the next 10 years.

This concludes my formal remarks. My colleagues and I will be delighted to answer any questions you may have.

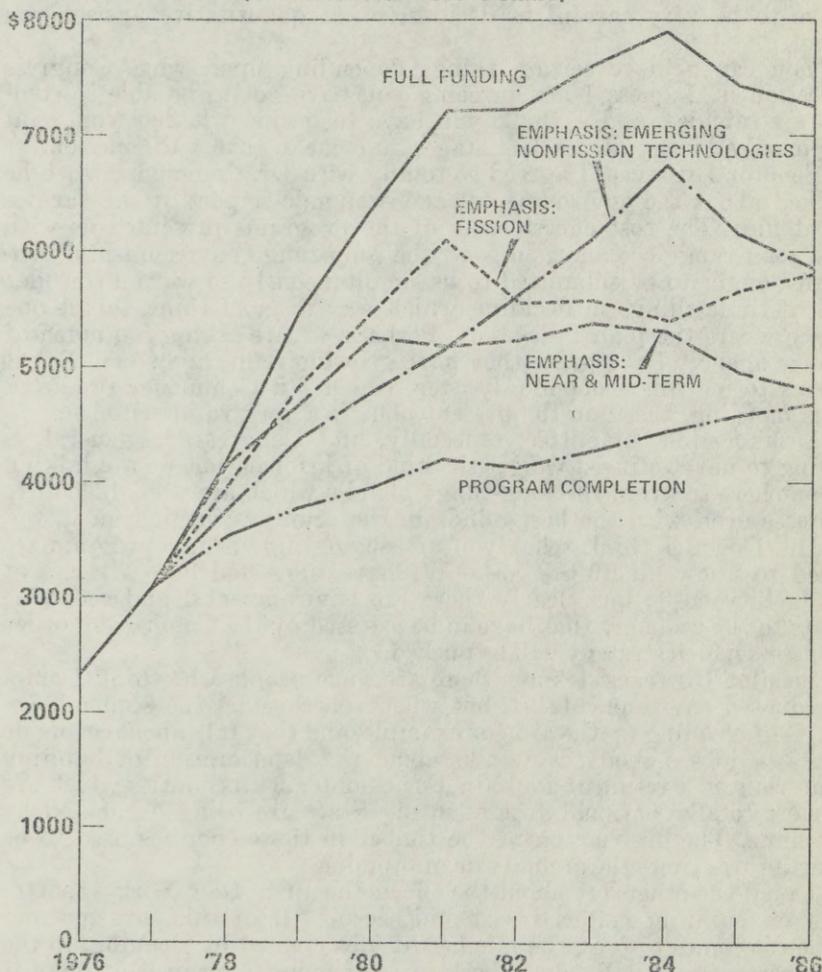
[The table and chart from Dr. Dowd's statement follow:]

TABLE I.—FIVE ENERGY R. D. & D. BUDGET ALTERNATIVES

[In billions of 1977 dollars]

Strategy	Cumulative 10-year budget authority	Peak 1-year budget authority	Year of peak
Base program completion	40.5	4.7	1986
Full funding	63.7	7.9	1984
Fission emphasis	51.3	6.1	1981
Nonfission emphasis	51.6	6.7	1984
Near-term and midterm emphasis	48.0	5.4	1983

Chart 1 Budget Authority for Alternative Research Strategies, 1976-1986
(In Millions of 1977 Dollars)



Senator BUMPERS. Dr. Dowd, do you agree what almost every witness that has appeared here has concluded, and that is ERDA ought to provide the Congress with various cost effective options? You are talking about the various strategies here. I guess my question is, don't you think the Congress has to have that kind of information from ERDA to make a sensible decision? In other words, we have to have something to compare their recommendations against.

Dr. Dowd. It is important to keep in mind what you want from a research and demonstration strategy. We are primarily asking for information. The kind of quantitative feedback you would expect

from ERDA would be related primarily to the kinds of information and the uncertainties they are reducing.

At the far end of the scale such as their commercialization program you are looking far more at the energy results, but when you are dealing with an R.D. & D. strategy, as mentioned yesterday, you have to be very careful in deciding what quantitative answer you want.

You can achieve certain things depending upon what Congress question is. I guess I am agreeing you have got to be able to compare strategies, and I think you have to decide whether you want primarily energy at the late stages, and make that a distinction.

Senator BUMPERS. I agreed so totally with Dr. Commoner when he talked about the environmental and economic impact of the various strategies. The cost effectiveness of the programs presented us with the long-range economic impact, the long-range environmental concerns, ought to be submitted to us simultaneously so we can consider all of those things in deciding which way to go. I think this is one place where the plan falls short. Perhaps we are asking too much of a new agency. I recognize they have growing pains and so on. But it seems to me this economic disaster, which Dr. Commoner predicted this morning, based on the present plan, is a very valid criticism.

I think this committee, especially, and Congress, in general, is going to have to insist we get the kind of information we are talking about here to avoid the long-range pitfalls which are very difficult to foresee even with the best minds in the country working on it.

Dr. Dowd. I think what you are suggesting in any program we need to know all of the costs. We have suggested here a series of budgetary costs, but clearly there are environmental and economic costs to the economy that have to be assessed by the Congress in order to assess which strategy will be pushed.

Senator BUMPERS. I know there are some people who think I am a hardnosed environmentalist, but when you consider the economic aspects of cleaning up the air, for example, and they talk about economic costs in jobs, nobody ever talks about the deterioration of building materials as a result of foul air. For example, two counties which are almost totally national forests in my State are being decimated by bromine. The destruction of the timber in those counties used to be worth three times the annual sale of bromine.

I read the other day about the effects the air in New York was having on building material, economic costs. All of this says nothing when it comes to jobs, the number of jobs created by cleaning up the environment. It will take a heck of a lot more to clean it up than it took to get it that way.

Senator Fannin.

Senator FANNIN [presiding]. Thank you, Mr. Chairman. I regret that I was not here throughout the full testimony.

Dr. Dowd. I appreciate the privilege of asking you a few questions. I am very desirous of a program being fully funded. I understand the problems you have in your agency or department in this regard. You have covered these full-funding strategies.

My problem is whether or not we do have the flexibility in any of these different programs. The objectives are very desirable and necessary, but I do feel we have lost considerable time in developing some of our programs because we have been learning so much about what

is going to happen and we are concerned about the amount of money being spent at that particular time. That particular budget, we have cut back on that budget to accomplish certain results, and I think it has been very costly for the future. Some of the programs have been delayed 4 or 5 years because funding is not available. I am thinking now of generation of power with solar energy. I am thinking about desalinization programs that could have been carried forward in connection with some of our other Federal-funded projects.

In your statement you give the different ways in which this might be accomplished; a full funding strategy, including the elements of the base program completion strategy and carrying out all major additional R.D. & D. projects identified in ERDA's national plan. In this particular recommendation, I don't know if you go on to cover them as to your thoughts, but aren't we really talking about a full funding strategy being absolutely essential in carrying through what we should do as far as getting energy self-sufficiency?

Dr. Dowd. I think it depends in part on whether the Congress feels the major demonstration projects that are included in ERDA's plan are all necessary to be undertaken by the Federal Government or whether more of them should be done by the private sector.

What we have tried to do is assess what the true costs are as best we could, of what those options would be should they all be funded.

Senator FANNIN. I wholeheartedly agree. I think as much as possible we should go to private enterprise for these projects being carried through, but we all know up to a certain point there are not benefits coming back to a particular company or they cannot see through the tunnel that we will say at this point we are going to have a problem.

We may not be able to gamble. I think to that extent the whole idea in fostering some of these programs we must take a gamble if we are going to be successful in meeting these goals.

ERDA does not provide, in its plan, an analysis of the total estimated costs of various ERDA programs. Is it your judgment that such costs would be helpful in an examination of ERDA's programs?

Dr. Dowd. Yes, sir.

Senator FANNIN. This would be helpful to your agency and department?

Dr. Dowd. I think it would be helpful to us in putting through information for Congress and be helpful to the Congress.

Senator FANNIN. I do certainly commend Dr. Seamans for the progress made. We all know this agency has not been underway for a long time. I think remarkable progress under the circumstances which involved switching over and the division of the responsibilities.

I was not here to hear Dr. Commoner. I am sorry I was not, but I understand he projected severe economic dislocations if the ERDA plan is followed. In your work do you project similar problems?

Dr. Dowd. I think Dr. Commoner was projecting a substantial increase in the price of energy. In a study we undertook, we did not look at that issue of the follow-on if the technologies were used to the price issue so I cannot speak to those issues.

Senator FANNIN. Personally, I feel we can have lower energy costs discounting the possibility of something happening as far as the imports are concerned. If OPEC decides we are going to have higher prices and we can't do much about it, I would go along with that projection.

I don't know what the projection was based on, but I do feel, with the breakthroughs that have come about in recent years, and I wish we had more development than has been the case, we should have some lower energy costs, especially when we are talking about what has been possible with coal, for instance, converting some of the plants.

I know in my own State, in Clarkdale, Ariz., they have converted a cement plant to utilizing coal. This has been a great help to them and a factor in their increased profits and lower cost of production.

I think if we really put forth the effort and have the reasonable and proper programs on our pollution controls—and I certainly am for a clean environment. In my own State that is what we have to sell. But at the same time I think you can be overly restrictive, and I have been at plants where they have had complete failure on their pollution equipment just because the demands were made upon them before the technology was developed.

I have we have gone down the path of tremendously increased costs in that regard because we did not use good judgment. But your analysis of what is being funded, has the consideration been the technology requirements?

Dr. Dowd. Yes; we primarily used those issues of technology that ERDA proposed to follow in their plan, and tried to get some feeling as to what the costs of that would be.

Senator FANNIN. Do you feel ERDA is adequately responsive to circumstances that require new directions in our energy strategy, or do you agree with the criticism that the agency is too technology oriented, wedded to expensive high-technology programs?

Dr. Dowd. I am afraid we really did not address that problem, Senator.

Senator FANNIN. I feel technology transfer should be a major goal. I have seen government projects and I just referred to one in my own State. When you spend a tremendous amount of money to desalinate the bypass water of the Colorado River in order to get along with Mexico, the Republic of Mexico, in their demands, it is not a national obligation or a treaty obligation, but it is something that has been thought beneficial to do, and we are going to spend perhaps several hundred million dollars on this desalinization program.

It is my feeling we can do a great deal by tying solar energy into the program, and we are trying to get this done. The Department of Interior is working to some extent on it, but I don't think they are getting the support of the other bureaus and departments for his purpose. They don't seem to be responsive and I am wondering why.

Dr. Dowd. I think one of the sets of papers we looked at in putting together our background paper was the relationship of the division requests to ERDA and the ERDA requests to the Office of Management and Budget.

What we did observe in that was some of the programs you have been speaking of, solar and conservation got much more severely reduced between the time they left the agency and the time they came to Congress at the President's request. The conservation program got slightly more than 50 percent of its request, whereas fission, the breeder reactor, got very close to 88 percent of its requested funds from the agency.

So there is a clear difference between what the agency has passed on to the administration and what OMB has ultimately put in the President's budget request.

Senator FANNIN. That is what worries me. Sometimes we have called ERDA to verify we needed a certain amount of money for a particular project. We have been trying to get that money for them. They have been down to OMB and have been convinced one way or the other they should have that amount of money, and when we get back, we have an understanding one way and we find it has changed if they don't request it on the second go-around. Yet we have a hard time justifying it. This has happened several times on solar. It has happened on geothermal.

It is my feeling we have a tremendous opportunity to cut the costs of power development. For instance, with geothermal, it has been proven in Geyserville, Calif., it can be done. The President visited the site, saw what was happening, and here we have a tremendous amount of power being generated there compared with what has happened in prior years. They are generating about 600 megawatts of electricity. They are 80 miles from San Francisco. That is about half the electricity used in San Francisco. They expect to go up to as high as 1,000 megawatts.

Several of those around the country could be very helpful in lowering the costs of energy nationwide because there are many areas that could be developed in geothermal, and we have not funded those programs adequately, and I blame Congress for this; nor have we made it possible for them to go forward with these programs, and we haven't held them back as far as leasing is concerned. But the funding has been held up, I think as a result of OMB.

Are you aware of what has been done in that regard?

Dr. Dowd. I think I do have some figures in a backup paper that was submitted to the committee. I believe it will show here—I think we have shown here the division requested \$102 million from the agency. The agency subsequently requested \$90 million, and the President subsequently requested from Congress \$50 million. So there is a substantial slippage as it went in, the three requests, ultimately from the program director to the Congress.

Senator FANNIN. This is one of the areas in which I say we have lost 4 or 5 years in carrying forth development of a great source of energy which is very disconcerting to me.

I appreciate your testimony very much. You seem very knowledgeable in what has been done. I am not in agreement with what OMB has done in many instances, but I also know the budget problems you have and the way in which you must decide what will receive priority.

I just hope you will check into some of these potentials and will be a little more realistic about the possibilities we have in doing what is necessary to lower the cost of energy.

Thank you very much.

Senator HANSEN. I have one question. Is the Congressional Budget Office able to develop an economic impact statement to show what effect the various costs of energy in the future may have on the economy?

Dr. Dowd. We have been able to do that. We have looked at some aspects of the increase, but mostly in the 2- to 5-year outlay. We have done that for the question of gas deregulation. We have prepared a report within the last 12 months on what impact that had on the economy.

We have not been able to do that beyond 5 years. The models are not sufficiently accurate.

Senator HANSEN. But you can give a fairly accurate forecast, in your opinion, for up to 5 years?

Dr. Dowd. We can give an educated guess with what will happen on price increases. We have done so. We would be willing to make that available to you on gas deregulation. We did a report reflecting on the impact of the previous energy increase on the economy and what portion of it inflation and employment was related to energy. We can supply that.

Senator HANSEN. I have no further questions.

Senator FANNIN. Thank you, Senator Hansen. I appreciate your being here today.

There will be followup hearings. This does conclude the hearing for today.

[Whereupon, at 12:05 p.m., the hearing was adjourned, subject to the call of the Chair.]

ERDA LONG-RANGE PLAN AND PROGRAM

FRIDAY, OCTOBER 1, 1976

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND WATER RESOURCES,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 3110, Dirksen Office Building, Hon. Dale Bumpers, presiding.

Present: Senators Bumpers, Stone and Hatfield.

Also present: Christopher Coccio, science consultant to the committee.

OPENING STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator BUMPERS. The subcommittee will come to order. This morning I want to welcome Dr. Seamans, and Mr. Legassie, and Mr. Marvin.

ERDA has one of the most important charters of any Federal agency in coming to grips with our deteriorating energy situation. The plan by which we determine our national research and development effort is important to me, to the Congress, and to the Nation. There is great concern among our citizens for the apparent lack of a national energy policy. These oversight hearings are intended to examine ERDA's part of the national energy picture. The need for positive action in the energy area has recently been underscored with another threatened embargo by Saudi Arabia unless we yield to their demands on arms sales.

ERDA's first plan was put together last year in the haste of a newly formed agency with a large-scale mission. The Senate Interior Committee chose to wait until this year to review the second version of the plan so that we would have a better prepared plan to consider.

We have reviewed this plan and we have held hearings earlier this summer where we listened to the Office of Technology Assessment, the Congressional Budget Office, the Council on Environmental Quality, and others who have had comments to make. These hearings and discussions developed some very important issues, issues which we would like to take up with you today.

The original ERDA legislation—Public Law 93-577, section 15 (b)—called for estimates of costs and benefits from the various technologies. It also called for estimates of economic, environmental, and social impacts of the various programs. These factors are critically needed by Congress in order to properly evaluate both ERDA's long-range plan and budget. Furthermore, it is important that the updated

energy plan be available when ERDA presents its budget for consideration and not after the fact. Only in this way can Congress properly review annual program budgets.

It has been our observation that these requirements in the original legislation are not being adequately addressed in ERDA's long-range plan. We would like to hear your responses today to these issues and also to discuss with you some of the information you have submitted to us along these lines in response to letters sent to you by both Senator Jackson and myself.

It is our desire to have the best plan possible each year at authorization time so that we can discharge our responsibilities here in Congress to provide the best allocation of the people's money in solving our critical national energy problem.

Dr. Seamans, and other members of your staff, I welcome you here this morning to talk about these matters. I should apologize for scheduling these hearings on the last day of the session; it is a very hectic time on the Hill. While we may not get into this in as much depth as I would like because of the time constraints, I think by asking some of the questions and by submitting other questions for your review and comment at a subsequent period we will develop a better rapport. I think the better rapport there is between this committee and ERDA and the clearer is the understanding of what the Congress feels its legitimate duties are and its needs as to what ERDA is doing, then the better we will be able to meet our mutual responsibilities.

So with that, again, we are pleased to have you and we are looking forward to your comments.

**STATEMENT OF DR. ROBERT C. SEAMANS, JR., ADMINISTRATOR,
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, ACCOMPANIED BY ROGER LEGASSIE, ASSISTANT ADMINISTRATOR
FOR PLANNING AND ANALYSIS, AND H. H. MARVIN, DIRECTOR,
DIVISION OF SOLAR ENERGY**

Dr. SEAMANS. Mr. Chairman, I agree with those remarks you just made concerning the desirability of working closely together. Mr. Chairman, I surely concur in your comments that we must work closer together as time goes on and that is certainly our desire, that is the reason I am very happy to have this chance to return before the committee.

Since we testified on July 22, you had quite a variety of witnesses. Some have been critical, some have been complimentary. We are particularly pleased with what we consider to be the balanced testimony of the Office of Technology Assessment. They were quite critical of our first planning document. Since then we have had a chance to address some of their concerns which in many cases were concerns of our own.

Today, they feel we have done a much more thorough job of looking at various energy systems, carrying out economic analyses, working through the planning, budgetary, and review systems in ERDA.

There is still a great deal of work to be done in the socioeconomic area. We agree with that and we are intensifying that effort. There is

also a great deal of additional work to be done in the environmental area. It is our view that planning—

Senator BUMPERS. Dr. Seamans, if I may interrupt you at that point. I take it you have probably read Dr. Commoner's testimony, or did you not?

Dr. SEAMANS. Yes, I did.

Senator BUMPERS. You mentioned environmental concerns, and we will come back to that later, it seems to me the two main thrusts he made was one which was patently obvious to all of us and that is the stabilization of energy processes absolutely essential to a viable economy. He thought that was the highest priority.

The other thing was he thought the plan, failed to take into consideration some of the real costs, namely, environmental costs. We will come back to those in a moment, but I wanted to know if you had seen those comments.

Dr. SEAMANS. Yes; and when I said some witnesses were critical, that is what I meant.

Senator BUMPERS. Please go ahead, Dr. Seamans.

Dr. SEAMANS. A general comment, we arrive at a general plan out of whole cloth but this is not the blueprint we are going to follow for all time. It must be a step-by-step process. It must be step-by-step because the world is changing. We are learning about the technologies. We are learning from the development work we are doing. Also it must be step-by-step because we must have inputs from a wide variety of different parts of our country. The kinds of discussions we have had in Atlanta, Seattle, Denver, Chicago, recently in San Francisco, next month in Boston, have been very helpful. These are open sessions where we present the plan and where we get the inputs from interested parties in a particular region. This is all part of the planning process.

It is our overall belief there is no one simple solution to the energy dilemma, that we must develop a variety of energy options both on the supply side as well as on the conservation side. We believe that is what the Congress feels and we believe we have been supportive of development in a balanced program.

Now, as often is the case—now I am talking about criticism—we are criticized for appearing to support some particular technology which a particular critic may argue is unsafe, uneconomic, or otherwise objectionable, and failing to emphasize a favored technology to the exclusion of all others which the particular critic prefers.

I think I can say almost everything we have been doing is criticized in this way and almost everything we have been doing has been supported in this way. It is our view that our analyses support the legislative basis of the Congress; namely, that a broad-based program is needed to meet energy needs, that we must allow for not 100 percent success, at least, in some of our R. & D., and we must have a choice, a societal choice, for the future.

We cannot prescribe in ERDA or in the Congress or in the Government exactly the way our population and our citizens are going to want to live 10, 15, 20 years from now.

At the same time, we can and should shift the Nation's energy system away from one dependent upon depleting resources, such as oil and natural gas, to one that stresses energy efficiency, to one that

makes maximum use of renewable and/or inexhaustible resources and major reliance of largely domestically available resources such as coal.

The thing we keep trying to emphasize is the transition which is necessary will take time, that there is a tremendous lead time in the energy business because it is so pervasive of our whole structure.

I have used the example many times. It took us 60 years to go from wood to coal and 60 years to go from coal to oil and gas. We don't have 60 years for the next transition. But we must be realistic.

To take one example, we have over 100 million automobiles. We want to improve the efficiency of our automotive fleet. But we only can improve 6 to 7 million each year. So the complete turnover of the fleet takes on the order of 15 to 20 years. Similarly, in every area that we look, we now have 66 million houses in the country. We believe strongly that the solar heating of the house itself, as well as of water, has great promise, but how long will it take to really get a large number of solar houses? We think by the year 2000 we may have as many as possibly 100 million houses, so that we can work on the some 35 million that are to be built—but then you have the retrofit problem.

We think we would be doing extremely well to get up to 30 or 35 percent of our residential buildings using solar in the next 25 years just because of the time it takes to first develop and then to put on the market reliable equipment, to have people feel it is economical to go ahead to make the transition and to do it in sufficient numbers that it will really make a difference in the total energy that is required in the country.

Senator BUMPERS. Let me make sure I am following your figures. Now, you say we now have 100 million residences in the country—

Dr. SEAMANS. We have 66 million.

Senator BUMPERS. But in the year 2000 you would say 100 million and you would estimate of those 25 percent being equipped with solar?

Mr. LEGASSIE. We are saying in total there would be some retrofit and some new. Not all new houses starting from today are in fact solar. So you want to get as many of the new houses as you can. We think perhaps by 1985 as much as 10 percent of the new housing starts from then on will be solar. Then one wants to go back and retrofit, but retrofit is less economical than doing it the first time, so you cannot retrofit all existing houses obviously, so the estimate we are using is perhaps a third of the total installed houses at the end of the century. Some retrofit, some because they were built that way to begin with, would be solar heating.

Senator BUMPERS. You have an estimate of what portion of the heating and air-conditioning requirements of those residences will be supplied by that system?

Mr. LEGASSIE. It will depend on the system that finally develops and the part of the country you are in. Obviously, we are then looking at cases that may run from 40 percent of the total heat load in areas where we don't have the best type of solar installation, to perhaps as high as 60, 70, 75, because there are some systems that can both provide solar heating and also make electricity simultaneously, so they could provide more of the heat load of the house.

Dr. SEAMANS. It depends a great deal on the cost of energy storage. It is not just a question of the average amount of solar energy that is available but of the probable time between good weather and bad

weather. As you go further north in a country the amount of solar energy goes down but also the time of protracted storms and bad weather go up, and you may run into—I know in New England in a period of a week or more you may not have any solar energy whatsoever. That means to take care of that period of time using entirely solar would be prohibitive from the standpoint of energy storage.

Senator BUMPERS. Let me ask one other question.

Dr. Commoner made the statement here the cost, that the value of homes conventionally heated are going to go down simply because the available sources of energy for those kinds of homes is going to become shorter and shorter in supply. Take fuel oil in New England, the prime source of heat. Those homes will go down in value. Those people apparently foresighted enough to put solar energy in at the beginning even though it cost a few thousand dollars more will recoup that because their houses will go up in value.

Do you agree with that?

Dr. SEAMANS. You have to make an investment to put in solar energy. Our figures show if you compare solar today with, say, electrically heated houses, depending on the part of the country, you come to the break-even point maybe in 10 or 12 years. If you compare today a solar house with an oil heated or gas heated house, taking into account escalation in the future and so on, it is going to take maybe 20-25 years before you reach the break-even point. So it is not an open and shut case.

We believe today it is economically advantageous to go ahead with solar energy.

Senator BUMPERS. Go ahead.

Dr. SEAMANS. That completes my general remarks. Roger Legassie here has several slides and a few comments he would like to make.

Mr. LEGASSIE. I thought it might be useful to spend a few minutes, and I don't plan a long presentation, to take you briefly through some of the scope of the planning and analysis activities which do underlie the plan, because there has been some concern expressed about whether we have been focusing on economic issues. That is the purpose of what I want to say.

First I would like to emphasize in terms of ordinary planning activities, the plan for energy is really an extraordinarily difficult job because of the long lead time and because of the enormous uncertainty that one faces in trying to look 25 years or more into the future.

We really don't know the demand for energy will actually exist as a function of time, we don't know very well the relative economics of many of the technologies, we don't know how environmental standards will develop over time and how changing environmental views will continue to impact our views of particular technologies.

There are choices to be made between how much centralized energy production we have and how much decentralized this Nation will choose to develop. The question of what preferred energy systems will be from a social standpoint can only be perceived at the moment. With respect to any technology, there is much uncertainty as to the date on which new technology will be available for introduction into the market, and even then there is uncertainty as to how rapidly that technology will be installed in the market once it is there.

There are international developments and the question of what imported oil prices will be and so on. All of these things are basically un-

known. We can put ranges around them. But we do not have good concrete material to steer by. So we have to plan on the conditions of uncertainty.

Therefore, we think we need more than one approach to a solution. We have a strategy that has main-line approaches, contingency approaches as well, we have to be careful about cutting off options too soon. The planning itself has to be iterative. We have to continually face at this time uncertainties.

Our system we are installing in ERDA does approach the examination of individual technologies and large energy systems as total systems. The major tool to analyze this as shown on the slide is the Brookhaven Energy System Model, which has been combined and extended to connect with still other major models. This is a very simplified version of this model and I don't ask you to struggle with the details.

The points I make off the picture are in a model of this kind we have a complete energy system. On the right end of that we start by designing all of the ways in which this country uses energy now, including the future. The list, in fact, in the model is much longer and more detailed than you see there, but we start by focusing on demand right from the beginning.

Over on the left-hand side, one tries to list all of the resources available. Again, that list is much longer. It lists solar, and other things such as biomass that we are also interested in.

Then we try to trace how these resources can go through a resource extraction, conversion, transmission, end-use device process all the way to meet the end-use needs. We have information on efficiency of the processes and the model also covers cost information and environmental impact information associated with each of these flows.

So we have in a single model economics, energy supply and demand considerations, resource considerations, and environmental considerations.

This tool was developed by the Office of Science and Technology, the Council on Environmental Quality, the National Science Foundation, and the Environmental Protection Agency, and others, so it is a tool that does have a great deal of validity in those parts of the Government and was not just developed as an energy tool.

We have presented scenarios developed with it in our planning documents and we did, in those documents, even ERDA-48, the initial document, include material in the appendix that presented the economic aspects and the environmental aspects that came out of those scenario ones. So we are trying to be responsive to the congressional mandate to deal with those areas of information supplied to the Congress.

We now have a major new set of scenarios in progress and we expect to report them in ERDA-77 which will be our next report and which we have targeted for publication about February 15. We picked that publication date based on the assumption the budget would be provided about January 21 and that is a 3-week difference in time which gives us a little time to turn around and get through the printing plant behind the budget and things of that kind, and we think it is responsive to the committee's desire to have the material submitted based on or concurrently with the budget.

So that is our target publication date and we would expect to meet that. The Brookhaven model we use has been connected to constraint models, input-output models of the economy, national growth models that concern themselves with growth, gross national product, inflation, things of that kind, and we have tried to show that schematically on these pictures so we really have a capability to tie results to much economic data concerning the economy. For example, Dr. Commoner was concerned about the effect of changing energy prices on the economy. ERDA is the energy agency that has developed the tool that allows this to be examined and in considerable detail, and as far as we know this is the first time that anyone has been able to put together such an iterative model that will allow examination of these kinds of questions.

We have made some runs on this and presented the results in ERDA-76. They are summarized briefly on the next picture. The point here is we examined two different cases of the future, both meeting a prescribed input target with respect to imported fuels and where one is trying to meet this target with price effects alone or with the combination of price effects and new technology.

One of the purposes of this was to get a new feel of the value of research in energy in terms of being able to control energy prices in the future, and also something about the cost-benefit ratio for R. & D. activity.

Senator BUMPERS. Mr. Legassie, may I interrupt you at that point to make sure I understand your chart. You have at the top, without new technologies energy prices would go up 30 percent. I assume as a result of inflated prices, energy demand will go down 13 percent.

Mr. LAGASSIE. That is correct. As the price of any commodity goes up our willingness to buy it goes down.

Senator BUMPERS. Are we talking about without new technologies in the year 2000 energy prices will be up 30 percent?

Mr. LEGASSIE. The numbers there represent the differences between two cases. In both cases energy prices go up, and the difference between a case that has new technology and one that does not is as energy prices go up an additional 30 percent, we would not want to make you believe as we run out of the cheap fuels—oil and gas that we used to be able to buy at \$3 a barrel but can't anymore—that we are not going to see an upward thrust in energy prices.

We believe that thrust is there. It comes not only from OPEC, of course, and their monopolistic prices but it also comes from the fact we then have to turn to less desirable fuels and fuels that are costly, whether they be coal, or nuclear, and so on.

Senator BUMPERS. In the year 2000, where it says new technologies, you say we can avert, you say in the year 2000 a \$180 billion loss in the GNP. Would you follow that up?

Are you saying we can avert a loss of \$180 billion by an expenditure of \$38 billion?

Mr. LEGASSIE. Let me explain that. There is a loss in the gross national product, in its present value, back to today it is \$180 billion actual value, it is actually much higher. That amount of money could be expended and used up by funding development of these at the level shown in the last line.

But if you spent as much as \$13 billion in 1976 and \$20 billion in 1985, and \$38 billion in the year 2000, you would lose all of those benefits because you would have consumed it by spending it for R. & D. To get the benefits back, the benefits would just equal the cost. There is a steady stream of money.

The point is that puts in some way upper limits on the maximum amount of money it would appear to be reasonable to spend, that is a saving that is there to be achieved; if we could get the same benefit for half of the money we would have a cost-benefit ratio of 2-to-1.

If we can get them for a third of the money we would have a cost-benefit ratio of 3-to-1.

What we are trying to say is the actual development program for the country as a whole, both private and Federal expenditures, is obviously at a lower level than that amount of money. If we can get those benefits for the kind of money we are now spending, we will have conducted an extremely beneficial cost-benefit activity for the country. Those benefits are there to be gotten and we are trying to run a program which will get them for the country.

Senator HATFIELD. Would you refer back again to what you incorporated in the new technologies?

Mr. LEGASSIE. We have tried to basically offer in these computer runs full sets of technologies that ERDA is developing, and then allow our computer model in this case to select the most cost-effective technologies from that set. So we have in this set, I think, a mixture of solar technologies, a mixture of nuclear and coal, and a mixture of synthetic fuel technologies.

They are some of the technologies ERDA is developing under the solution in this case run and do result in a reduction in future energy prices and do result in improved employment. There is additional data, I do not have a slide here, it reduces inflationary impact, and it provides a saving to the country in gross national product, which means we can have a higher GNP which will improve the vitality of our economy as opposed to trying to meet the same energy situation with price effects only.

This is a comparison study we have done. The purpose of this is to show there are real benefits for the country of an economic character to be achieved by an R. & D. program which is successful.

The cost of the actual program as we see it will be much less than the benefits that can be achieved from it. This is the kind of investigation we are making. It is very economics-oriented. It is very much concerned with the question of what the benefits and what the costs are and what the impacts on employment and economic viability of the country are.

Senator HATFIELD. Does that include fusion as well as fission?

Mr. LEGASSIE. Since this goes through the year 2000, fusion is not there. Our estimates are we will have a demonstration plant running in fusion, but the estimates would have to be 20 or 30 years after that.

Senator HATFIELD. So all of your projections are hypothetical, aren't they?

Mr. LEGASSIE. I started my presentation by emphasizing the enormous uncertainty with which this planning is being done. All projects are extremely uncertain and the way the analysis works itself and the R. & D. program itself, we are trying to investigate with paper and pencil, some alternatives and what the consequences might be.

Senator HATFIELD. I am troubled about what your conclusions appear to be on page 114—perhaps I misinterpret that—the great reliance upon fission.

Mr. LEGASSIE. I think we see fission as a technology option for the country and in fact if I could, shortly in my presentation I would try to address something in the area of your remarks.

We are trying to develop in accordance with the congressional mandate, as we understand it, a balanced program which makes sure we develop not just one option but many options that are available for use by the country. In fact, if you like, I will leap right to some material there that may bring this out.

Senator HATFIELD. All of these projections as a hypothetical then, really come down to a persuasive argument that \$180 billion is going to be saved by the investment of these projections to the year 2000. Again, if I may ask you to be patient, I would like to ask you to go over that. To me those are almost irrelevant figures. How can you be sure if everything is hypothetical? How can you project such specific figures?

Mr. LEGASSIE. In fact, I tried to say just what you are saying. We don't know any of this with any precision whatsoever.

Senator HATFIELD. Then we really should not draw any firm conclusions from it?

Mr. LEGASSIE. No. And I am not presenting this result as some great conclusion from Mount Olympus. I am trying to present the result of an investigation as much as one would present the results of an R. & D. test. We are using the model and analyses to investigate this territory. It is one point on a surface whose dimensions we don't know very well.

We have a large set of additional studies in progress to try to understand this territory much better. So I am not trying to present to you some answer as much as I am to say we are trying to ask these kinds of questions.

To the extent we have confidence in anything whatsoever, the kinds of results that are coming out by asking these kind of questions presently look like this, as we are showing them to you. But we are going to go back and probe deeper and deeper on those questions and do more and more case studies and engage more and more people on these issues.

I think we, indeed, have a long and difficult road to travel in order to obtain a confident perception of the future, and we are not saying that we have that at all. We are trying to present where we are.

Senator HATFIELD. I would make one observation. I would hope that all of these projections and studies and what-have-you, that incorporate such a great reliance on fission, in no way retards our pushing through on the fusion thing.

Mr. LEGASSIE. No, sir. In fact, the basic posture in the analysis has been to do what we call alternative scenario development, not to just have some kind of base that has a certain amount of nuclear or a certain amount of coal in it, but we have studied cases and we have presented them in ERDA-48, a case in which the emphasis was on the avoidance of—the emphasis on nuclear and on decentralized technologies and renewable technologies. That is one of the alternative scenarios we want to look at and study very carefully.

Now, perhaps you would like to look at where the money has been going. I have two charts. The first will show absolute dollars, and I am applying the increment over the 1975 budget to the 1977 budget. ERDA was not in existence in fiscal 1975, that was about a billion dollars. We have gone up now to over two billion. So a billion dollars has been added by ERDA and Congress to energy R. & D. over this 2-year period.

I would like to show you \$300 million of that went to fission, another \$300 million into fossil work and another \$300 million into what I call renewables there but is in fact the solar, geothermal, and conservation activities and about \$200 million into fusion. This is a distribution of the nuclear; about half went into the continuation of the breeder work which was a mature program underway; and the other half has gone into address the new issues of waste management, chemical processing, and so on.

Now, you can look at the same data in another way. That is in terms of the factor of increase for these various programs with these absolute dollars laid out. As you can see, the dotted line there says the ERDA budget as a whole essentially doubled in this 2-year period.

Second, the fission work grew at less than the average rate for the entire budget, even including this new thrust on waste management, for example, which had not been pursued vigorously by the agency but which ERDA feels is a public issue that must be addressed.

The fusion budget has grown at the average rate for the entire ERDA budget, and fossil has grown about 50 percent faster than average, and renewables, as you see there, by factor of 6. So we really have been—as we come into 1977, which is the first year in which ERDA has a full budget of its own because its 1976 budget was split—trying to put new money into areas which have been neglected in the past and in this kind of distribution so we will get to a more balanced total budget in terms of distribution of funds.

Senator BUMPERS. Mr. Legassie, Senator Stone has another appointment. He has a question or two he would like to ask at this point.

Senator STONE. Thank you, Mr. Chairman, and Senator Hatfield.

First, let me ask you how much of your money from coal gasification projects are for high Btu, and how much are for low Btu?

Dr. SEAMANS. I think they are split 50-50.

Senator STONE. In the low Btu, how much has been contracted out to boiler manufacturers?

Dr. SEAMANS. I cannot give you that figure.

Senator STONE. Has all of it been connected to boiler manufacturers?

Dr. SEAMANS. No. We have been working both in the high Btu and the low Btu with the gas transmission people, we have been working with the American Gas Association, we have eight pilot plants all told.

Senator STONE. How about in the low Btu area?

Dr. SEAMANS. I would have to check on that, the distribution—I recognize the American Gas Association is much more interested in the high Btu.

Senator STONE. Some of the industrial users, and utilities are more interested in the low Btu, and definitely the environmentalists are more interested in the low Btu because of the greater ease and greater

effectiveness in cleaning up the air. Am I correct in that, Dr. Seamans?

Dr. SEAMANS. With the low Btu, you have to use it within roughly 20-25 miles of the location where you gasify.

Senator STONE. Locations—

Dr. SEAMANS. Yes.

Senator STONE. But it is cleaner?

Dr. SEAMANS. It can be, it has advantages and it can be used that way. We are looking at both alternatives and a median as well.

Senator STONE. I am very interested in an analysis or statement about the way you give out grant money. Some industrial people have told me that instead of maximizing your best prospects, you minimize dissent by giving everybody some. What do you say to that?

Dr. SEAMANS. It is sheer baloney. We have run competitions on these jobs. They are not grants; these are cost-shared projects wherein the pilot plants, they are roughly two-thirds Government to one-third private funds. We solicit proposals and we make a determination on the basis of cost and technology and environmental factors and take into account all of the factors that should affect the decision.

Senator STONE. Thank you.

Senator BUMPERS. Mr. Legassie, would you continue, please?

Mr. LEGASSIE. I think I have been trying to say there is a lot of attention to economic consideration in these total systems studies. We have also initiated new studies relating to energy life styles so we begin to get a much better understanding of our territory.

We, of course, use other models in addition to representative systems, so I don't want you to think we are stuck with some single approach to this problem. We have also used this to investigate regional energy situations, and ERDA has a major regional studies program underway under Dr. Liverman, which similarly examines these kind of questions.

The work we are doing here, which I will stress again, contains within a single model economic, environmental information and is being copied by others which I think is the best measure I know, when an independent evaluation says this is a good approach.

For example, the European Common Market, the 18-member countries of the International Energy Organization and the individual State organizations in the United States such as the California Energy Commission, have all come to use this approach which ERDA has made available to them as representing a good way of analyzing the energy problem.

We have defined and are implementing a systematic effort to evaluate the magnitude and timing of energy benefits for specific technologies. Of course, then you have some of the fruits of that in a letter which Dr. Seamans has recently signed to you. These efforts are supported by both general and specific studies in market penetration phenomenon.

We have implemented what we call a scoring model process in the conservation area for energy efficiency technologies. We can effectively sort out and determine those proposals we receive that have the maximum potential for energy benefits for the country, and pass the economic tests, so they can penetrate the marketplace, and so on. We are now engaged in a further effort in policy structuring in our conservation programs so we can further strengthen this program and maximize the opportunities they may contain for early results.

We also do market studies which are economic studies which explore energy systems from the standpoint of the user, whether this user be the electric utility company, as was the case with the first study which we never have essentially completed, or whether he be the pipeline owner which is the second study, or the residential and commercial sector which is intended to be the third study. We have another study planned around the concept of looking at the entire concept of small energy systems, decentralized systems, as a specific way of making energy.

The studies include market size and economic cost estimates. Other measures of quality such as environmental attributes are included. The first study, the utility study, we would hope to have available in draft form for public review so we can get some external criticism of it in about 30 days.

We are doing venture analyses, which are again economic studies based on the point of the view of the marketing organization, the company that has to market the technology to see the kind of barriers he faces in doing this in the private sector world, and to thereby examine the issue of incentives that may be applied to facilitate commercialization of the technology and we are doing benefit cost studies.

We have developed and are implementing a formal program strategy and planning process. We now have first drafts of about seven program strategies and seven program plans which have been put through on a pilot basis and still require some substantial reworking before we are completely happy with them.

But we are about to move into the second phase of this and we expect a call for formal plans for about 90 percent of the remaining programs within ERDA, so a year from now we should have essentially been through this process in detail for every program.

We are also initiating an environmental development plan process. This has been defined and is in the early stages of implementation now. Its purpose is to make sure the environmental plan is in time synchronization with the plans for technology development so we don't bring the technology along and then find because there are environmental issues which have not been faced, that we are not able to move that technology forward.

We want to establish a very close coupling between the environmental development work and the technology development work in the agency.

All of this effort is correctly identified as winners and losers, sharply defining our priorities, defining R. & D. policy issues, and as an input to the budget decisions.

I have also shown you the viewgraphs to show you we have been offering the size and shape of our budget based on the fruits of this planning activity. So there is a connection between this analysis and planning activity and how our budget is coming out. At least we think there is.

As a direct result of this planning activity, ERDA has developed and public adopted several major policy positions to guide its program progress, and I would note briefly what some of these are.

First, we said we need a broad based energy technology program. We have identified the need for Federal attention to issues involving the light water reactors which were previously neglected by the

agency. We first assigned the solar technology effort to that of a major priority inside the Federal program; we took the position the energy efficiency technologies needed to be put on an equal basis with the highest priorities of technology from the standpoint of the national effort; we directed attention at the importance of R. & D. efforts be conducted in such a way as to maximize the likelihood of actual technology use, which means both concern about the private sector commercialization process and concern about consideration of the environmental, social, and economic issues that lay around the entry of a technology. We have also taken a strong position on recognizing the regional nature of the energy problem, the corresponding importance of State and local government to the public.

All of these policy positions in addition to analytic results have been coming out of our planning effort.

I think we have been placing increasing effort on the social, economic, environmental issues. I think we are advancing the state of the art in the light of the long-time horizons we have to look at; I think we still have a long way to go I am not going to claim we have the best possible program we could have in this area, but I think we are really attacking this problem with a great deal of effort and emphasis, and we are glad to have the opportunity for you to have some more appreciation of this program.

Senator BUMPERS. Mr. Legassie, I am one of the people who feel we have not even really begun to hit the greatest source of energy supply in the country by saving what we have through conservation.

Your letter to us states "the energy saving expected in 1985 through building and consumer products"—that is through conservation of building and consumer products—"has been reduced from 31½ to 2 quads." In spite of your placing conservation, at least you say you are placing conservation on the highest priority, we are spending, according to the plan, about \$250 to \$270 million through 1985 for conservation, compared to \$10 billion on the breeder which is not going to supply any energy in 1985.

In that connection, I had the staff prepare a chart here which I want to show you. It is a rather crude one. It is probably flawed. It was put together rather hastily. Can you see that from there?

Mr. LEGASSIE. I think so, pretty well.

Senator BUMPERS. Let's take it from over here. This is the breeder, this is fusion, biomass, this is conservation, and this is oil shale. We left coal out because coal shows a little bit of a distorted picture.

What I wanted to do was ask you questions about the breeder, I mean about fusion and breeder reactors as compared to conservation.

Now, the blue line here are the quads of energy, and these are the upper and lower ranges which you point out in your letter to us and the dark red line is on the cost—for example, on the breeder reactor, you say \$9 to \$10 billion.

Mr. LEGASSIE. I understand.

Senator BUMPERS. You can see here that breeder reactors is going to cost between \$9 and \$10 billion and that is only through 1990, and it is going to produce, maybe, 2 quads of energy per year at some future date.

Mr. LEGASSIE. That would be in the year 2000.

Senator BUMPERS. Correct, the energy estimates are predicated on the year 2000, and the expenditures will be made between now and then.

Then over here in the conservation area, we show between \$200 million and \$700 million, being spent to save 3 to 6 quads energy per year.

Then over here on biomass your expenditures through the year 2000 of \$0.3 to \$1.8 million to produce 2 quads per year. When you get to the cost-benefit ratio, which we are trying to get to make these decisions, it looks like fusion and fission are made less favorable than conservation.

When did you say we would get some energy from fusion?

Mr. LEGASSIE. We expect to have a demonstration plant running by the end of the century; large-scale use would probably be in the following 20 years.

But if I could say so, I think your chart is illustrating the danger of estimates of this kind. We find as we take estimates of the energy savings in the year 2000 and the answer is for fusion, there is no energy saving. On the other hand, this is the extent of a lengthy program and the cost-benefit is zero over \$15 billion, and this is a bad program. I don't think you can think so—you can't think so about the problem.

What we are doing is following the mandate of the Congress in recognizing there are different time periods which our development program has to address in the next 10 years, between now and 1985. Here are conservation opportunities to be seized and there have to be programs to go after them.

There is the mid term, 1985 to 2000, and there are needs in that time frame as well which require more difficult development programs. They have to be started now if we are going to address those 1990 needs, and similarly, there are needs after the end of the century.

The fusion program is an example of a program that is trying to get this country, one of the ways we can get to an inexhaustible energy source after the year 2000 is using fusion technology, and that program is more complicated and lengthy in terms of what it has to accomplish. So it has to be started now also if it is going to meet the targets of that time frame.

So we have a near-term, a mid-term, and a long-term program, and they all have to be running now if they are going to produce or have a chance to produce results.

Dr. SEAMANS. If I may add one thought on the long term. In our first planning document, as well as the second, we pointed out for the long term we believe there are three possibilities: one is solar, one is fusion, and the third is the breeder. There are very strong concerns in certain quarters that we were relegating the breeder too far out in time. We should be pressing ahead with bringing the breeder in much sooner so it can make a major difference before the end of this century. That was our analysis, that not until the year 1986 when we have finished our breeder demonstration and done quite a bit of additional work in other areas, such as the environmental, if we don't make the decision until 1986 to commercialize we can't expect much return until the year 2000.

Our most optimistic measure today is we might have 30 to 40 of these reactors systems by that time. The real payoff on a breeder is

in the next century, as we believe the fusion payoff will be, as we believe the payoff from solar on a major scale.

Senator BUMPERS. Dr. Seamans, let me ask you a question regarding the budget. Would it be possible for ERDA in February when they submit their next plan to give us the annualized future budget and energy benefits for the various programs. Right now, we have energy benefits only for the years 1985 and the year 2000, and we have only one lump sum number for your estimates of the upper reaches and the lower levels of the funding that is going to be required of these various technologies between now and the year 2000.

Really, we have a need for this information as the authorizing committee. But it appears to me the Budget Committee, the Appropriations Committee, the Budget Committee especially, would like to have those kind of figures and it might be helpful to us in making our projections on an annualized basis so we can see what we are talking about on a year, 2-year, or year-by-year basis. Is that impractical? I am really asking an honest question. I really don't know.

Dr. SEAMANS. In carrying out our calculations and so on we have picked these particular dates. We can interpolate as we do by drawing curves the extent to which we could really detail in on an annual basis the next 25 years. It is a question of whether it is really worth that effort.

I think the annualization you are looking for perhaps in the next 4 or 5 years as to what our projections are going to be in one of these areas, and these, again, are difficult because each year depends on the previous year.

Right now, wrestling with 1978, we are not quite sure what is going to happen in fiscal year 1977, we haven't gotten the authorization bill yet. I am hopeful we will get it today. But I am sure we can provide more information than we have in the past on an annual basis and we could look into that carefully.

Mr. LEGASSIE. I think another obvious point is if you go out more than just a few years, what you find is you are adding all of the programs up as if each one would in fact continue as seen by its proponent at that moment. But you would expect as you really go forward in time that some programs can produce good results, other results are less favorable, and you really would alter the composition of the budget through time based on your experience in running the program.

You cannot see that. I can go ask these programs to tell me its projections. I can add all of those projections up but the end result would be larger than the budget in fact in those later years, because we would not want to continue all of those programs that way.

Senator BUMPERS. I see what you are saying. Your point is well taken. I can understand the difficulty of that. We don't want information that can be misleading. If you tried to do it, it might be misleading. I understand what you are saying.

The Congressional Budget Office, I think, would like to have that. If you can't do it on an annualized basis, I think the least number of years you think would be feasible whether it be 5 years, or 4 years, or something like that, would probably be a little bit helpful. But I do understand your problem and I am not insisting.

Mr. LEGASSIE. We will see if we can get you more information of the kind you are asking for.

Senator BUMPERS. Let me ask this question. One of the things that occurs to me that we are doing we have a tendency to look at the cost of new forms of energy relative to natural gas and crude oil. In other words, we are saying synthetic fuels especially should not be developed unless we can see an mcf equivalency of something like \$2, which I assume is about what we are going to be paying for liquified gas. It occurs to me that we may be making a bad mistake by subconsciously, at least, keying in on those kinds of ideas.

Ultimately, whatever the cost is, we have got to produce it regardless of what the Btu equivalency might be or what the kilowatt cost might be. I think we ought to be aware that in the foreseeable future we will have coal available, and we will be able to convert coal to syn fuels. If we were to judge the conversion processes to a price-controlled energy cost it could be a bad mistake.

Dr. SEAMANS. I agree with that very strongly. I feel we should be moving ahead more aggressively with synthetic fuels.

Senator BUMPERS. Do you favor the loan guarantee program?

Dr. SEAMANS. Yes. I fought very hard for it. Of course, we were not successful in the House by a vote of 193 to 192. There are various reasons why we were not successful in the House. Some looked at it as Government meddling where it should not meddle; others looked at it as an open handshake for private industry.

There is no question as time goes on and natural oil and gas are depleted, costs are going to rise. On the other hand, with the use of shale, which is essentially untapped, and a great deal of additional coal, and an opportunity for a lot of new ways of doing things in the conversion process, I believe that although today the cost per barrel or per cubic foot is higher than natural gas, in time because natural gas is going to go up in price that these will be bound to become more competitive. They give us time for transition over to new resources and will stretch out for many years to come, the supply of energy in the forms we now use.

That is very important. The investment we have in this country in pipelines, in automobiles, in refineries, all the rest, I think we ought to utilize that as long as we can. I think that is the cost effective way to proceed.

Senator BUMPERS. Do you and your staff and top management officials there, have you talked about the criticism of over-emphasis on electrification as opposed to, say, heating and cooling?

Dr. SEAMANS. We have given a great deal of thought to the whole matter of electrification and what it may mean to the country. Of course, it will require considerable effort on new technologies that would permit us to transmit electricity without having great swaths through forests, lands, and the rest of it. Certainly we want to do everything we can to minimize too rapid growth rates of electricity, but we believe we must plan on the increase of electrification per year that is somewhat greater than the increase in our use of total energy. We look at all aspects of that. This will come; it certainly comes when you think of fusion. It certainly comes, when you think of nuclear, and even with coal.

You were talking a short while ago about doing as many things as possible, as close to the sites as possible, using low Btu gas, for example. That is all fine but it means you have got to ship a great deal of coal around the country to do that. In a lot of cases, it is better to electrify and then transmit the energy in the form of electricity.

Senator BUMPERS. Is there any way, because I don't think Congress can really sensibly deal with this until it has this factor—is there any way, especially in the syn fuels area, for you to give us some environmental costs, not only in dollars and sense, but in health costs?

For example, I have heard, and this may be erroneous, but I have always heard that most of the German workers who worked in the lurgic process of converting coal to oil in Germany in World War II, virtually all of those people came down with cancer within 10 years after they worked in those plants.

Dr. Commoner referred to the highly carcinogenic elements in conversion, liquefaction and gasification processes. Those are environmental concerns but not necessarily documented in dollars and cents. There are others people talk about, for example, air pollution, which we are debating on the floor right now, and the effects polluted air has on the facades of structures in this country, whether they are stone or steel.

Those are costs that have never been computed but they appear to be staggering and we should have an estimate for them before we spend a tremendous amount of money. I have mixed emotions about the loan guarantee program, and I have talked to some of my colleagues who have strong feelings on both sides of this, but I am inclined to agree with you on the loan guarantee program for synfuels, I think it is a technology that must be developed in this country.

But the questions right now are two kinds of costs; those we normally classify as environmental and the other is health. Is there any sensible way you could enlighten us on that so we could have some feel for what we ought to be doing?

Dr. SEAMANS. On the matter of health effects, I don't actually know what the statistics are as far as the German workers are concerned. I have checked with Dr. Liverman who is in charge of our environmental program, our safety program, and he has never heard the kind of statistics you just mentioned.

However, it is known coal can produce cancer if one comes in too close contact with it for too long. I think you should have more of an expert than I am here to discuss it in detail. It is my strong belief that it can be handled properly when it is recognized what the possible outcome can be and when proper precautions are taken in plants to protect those who are working.

It appears that this can be done with relatively small increase in the cost of operating the plant. It should obviously be done, we want to protect those involved.

Mr. LEGASSIE. I might add a word there. There is, of course, a draft environmental impact statement on this program. It has examined and tried to define the environmental issues, all of them, including the carcinogenic question which you just expressed concern about and has set this forth very clearly in terms of the attention that has been paid to this matter.

Part of it would be done in the construction of such facilities under a learning program and would involve a very close relationship with the Environmental Protection Agency, the Occupational Health and Safety people, so one can really make sure and address the question to the experience of getting at how these plants would really operate, whether or not these matters can be adequately taken care of. That is one of the reasons why we take the view we do toward the R. & D. program, this is one of the matters on the agenda that could make or break the technology that such a program has to address and would involve participation of other agencies in this matter.

Dr. SEAMANS. To give you some idea of the breadth of the studies we are carrying out, we have known an increase in the amount of carbon dioxide in the atmosphere can increase the temperature, a sort of greenhouse effect. It is a very, very complicated type of study. It is impossible today to say authoritatively what would happen over long periods of time if we go more and more to the use of coal.

But we have initiated such studies. We are involving the most competent people in the United States to look with us at the possibility of course, a possibility that could have serious consequences.

Senator BUMPERS. One thing I have devoted a lot of time to here is a bill, originally a bill which later became an amendment to the authorization and that was, as you know, the Energy Extension Service. Senator Church instituted the plan and the small grants plan.

I have discussed with some of you people how we might implement this. The suggestion has been made the Energy Extension Service ought probably to be put in place in the form of pilot projects in a few selected States.

I do not know if I totally agree with that or not. I can understand ERDA's reasoning, but the people of this country, they all want to become energy independent, and they are all reminded constantly we don't have a national energy plan—which, incidentally, is not entirely true, we are coming close to developing a plan, as close as we can get to a plan, the information and technology we have available.

Politicians like to scare people and that is about as good a way to scare them as any, to tell them we don't have a plan, they are all going to freeze to death one day.

I remember Lyndon Johnson told me one time when he was first elected President, the first thing he did was call all these high priced executives from the National Association of Manufacturers and said you have got all these lobbyists in \$200 suits roaming the halls of Congress to keep the hell scared out of the legislators; if you want to save money you can fire them all—I'll scare the hell out of them.

It occurs to me while we are developing the Energy Extension Service, that people are frightened by this threatened oil boycott of the last few days, and it has got people all exercised again. I think they would like very much to have somebody knock on their door and tell them how they could either stabilize or minimize their utility bills and give them a cost benefit analysis in their own homes, in their own businesses as the Energy Extension Service could do.

The Energy Institute concept with various States developing locally needed ideas would cost little, yet you could glean a great deal of good information from these State programs. I still feel various

States, depending on the latitude and so on, have very unique problems that ought to be dealt with in a very unique way.

But I maintain within 24 months, for example, if that Energy Extension Service were funded at \$100 million instead of \$71½ million or even \$200 million—within 24 months, I honestly believe through a concentrated educational program knocking on doors, assisting people in developing cost analyses, for their individual problems, we could save the equivalency of the Alaska pipeline within 24 months.

Here we are spending \$8 billion for the pipeline and God knows whatever 2 million barrels of oil are worth a day, if we had gone into this on the basis I wanted to go in on this, so it would be in operation at the time the Alaska oil started to flow, those two things would make a significant dent in the energy problems of this country.

Do you essentially agree with what I am saying, Dr. Seamans? Feel free to disagree.

Dr. SEAMANS. We certainly agree some form of extension service is essential. We have started, as you point out, with a couple of pilot models, exploratory models, largely associated with our conservation program, in anticipation of an authorization bill and the amendment you have just referred to, we have initiated a special task force which I met with last week, headed by Dr. Eric Willis, who is the Assistant Administrator for Institutional Affairs, to really get down to cases and see how we should proceed to get the maximum benefit out of the \$71½ million that is in the authorization.

I think we need to do more than carry out just a couple of pilot studies. It is not clear yet to me, at least, that we ought to proceed State by State. I think some regions in the country have a natural tendency to band together. New England has, the Rocky Mountain States have, and so on.

I think we ought to be adaptable enough to work with regions the way they have naturally tended to tie themselves together. These are the kind of interrelationships we are looking at. We do feel it is important and we do plan to move ahead aggressively.

Senator BUMPERS. Dr. Seamans, we might want to submit—we are going to issue a report based on these hearings, and give a short summary. I want to thank you very much for your cooperation. I have tried my best not to impose on your time. I feel sorry for some of the Cabinet members and other managers from the executive department who are constantly called over here and valuable time taken away from their duties to testify. And yet, it is just a necessary part of our job, we have oversight responsibilities. I don't believe in leaving the war to generals and I don't believe in leaving science to the scientists.

We appreciate it. We will probably submit a few questions in writing to finalize our feelings about the thing. We look forward to getting your second plan in February. As you know in my correspondence with you, we told you we had the cart before the horse, appropriating the money before we got the plan. We look forward to getting it in February and that will give us an opportunity then to do a much more sensible job of budgeting.

Thank you.

[Whereupon, at 11:30 a.m., the hearing was adjourned.]

