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U. S. ENERGY R&D: POLICY AND PRIORITIES[1]

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I shall speak about energy R&D policy and priorities; however, to do this intelligently one must first talk about energy policy. The primary purpose of energy R&D is to help implement and advance energy policy; but the matter is somewhat complex. Energy research, hopefully, reveals new possibilities and new options that ought to influence energy policy. Thus there must be a continuing dialogue between energy policy and energy R&D because they are clearly interdependent.

Present U. S. energy policy is largely dominated by our commitment to energy self-sufficiency - that is, to Project Independence (P. I.). But this commitment does not constitute our entire energy policy: we are, even now, making decisions concerning nuclear plant siting and conservation that go much beyond any immediate commitment to self-sufficiency. These decisions will commit us over the long term to certain patterns of land use, as well as to certain life-styles that are in some degree independent of our commitment to Project Independence.

Both energy policy and energy research and development strategy are presently in transition, largely because new governmental structures for

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energy are being created. The Federal Energy Administration (FEA), with John Sawhill as its Administrator, has been established, and FEA is responsible for providing and implementing the Government's energy policy. Congress in the authorizing legislation provided a two-year life for FEA whose concern is with shorter term energy policy such as allocation of scarce energy supplies and implementation of Project Independence. But these short-term commitments carry with them long-term implications, and therefore FEA is inevitably drawn into long-term energy policy.

At the same time, legislation which will establish a new Energy Research and Development Administration (ERDA) is threading its way through Congress. It is difficult to predict when this bill will be enacted into law, or exactly what its nature will be when it is reported out of the conference committee. However, essential elements of ERDA are rather clear: it will consist of most of the Atomic Energy Commission (but without AEC's regulatory and licensing functions); the Office of Coal Research and the energy programs of the Bureau of Mines conducted above ground (such as the synthane pilot plant); the solar heating and cooling as well as the geothermal programs of the National Science Foundation; and, depending on whether the House or Senate version of the ERDA bill prevails, the automotive emission and stack gas technology of the Environmental Protection Agency.

Thus, when ERDA and FEA are both functioning, our energy policy and energy R&D activities will be better organized; but there will remain the matter of assuring that ERDA research policies are consistent with FEA energy policies; and, further, that FEA energy policies take adequate

account of the new options created by ERDA's studies. This will require coordination, some of which is now being done in the Office of Energy Research and Development (OERD).

Project Independence is the central element of our shorter term energy policy. FEA has established a large P. I. task force to decide, first, exactly what the goals of P. I. should be; and, secondly, to work out plans for implementing P. I. These plans, known as the P. I. Blueprint, are scheduled to be placed on the President's desk in November. Groups designated as Conservation, R&D, Fuel Supply, Policy Analysis, Quantitative Analysis, and International Assessment are creating this massive Blueprint. Such an attempt to visualize an energy future constrained by a commitment to self-sufficiency, and then doing the most that can be done to put these aims into practice, is probably unprecedented in our free economy system.

The most important - and the most difficult - part of the exercise is the precise definition of self-sufficiency. Given the long lead times in producing new sources of prime energy, it seems quite unrealistic to expect that by 1980 we shall not import any foreign oil. A more realistic goal would be to keep U. S. imports of foreign oil below some 15 or 20 percent of our demand for oil, with not more than one-fourth of this amount coming from one section of the world. We would then enjoy invulnerability from political whims of possibly unfriendly oil-producing states.

In addition to the Blueprint, P. I. includes an Action Plan: a series of things that can be done, almost immediately, to increase our supply of

domestic energy and to reduce our demand. Many such actions involve breaking through bureaucratic deadlocks or bringing together parties with conflicting aims - for example, environmentalists and shale oil developers - and resolving their differences.

What can research and development do to help achieve the aims of Project Independence? This question was addressed in "The Nation's Energy Future" (NEF), a report presented to the President by AEC Chairman Dixy Lee Ray in December 1973. Much of our thinking about energy R&D has been structured by this document; and many of the priorities we have established were strongly influenced by it.

In its barest essentials, NEF projected an energy demand for 1985 of about 120 mQ (1 mQ = 10^{15} Btu), somewhat higher than present projections. (Interestingly, since 1952 there have been at least 133 independent projections of supply and demand, all of which concluded that we would have an energy shortage of significant proportion.) NEF further stated that by increasing nuclear energy installations to provide 16 mQ, increasing domestic oil and gas production to provide 56 mQ, and greatly expanding our coal mining, we could come within 14 mQ of self-sufficiency by 1985. This short-fall of 14 mQ would then be made up by conservation to the extent of reducing our energy growth rate from more than four percent per year to some three percent annually.

"The Nation's Energy Future" proposed an $11,000,000,000 Federal budget for energy R&D over the next five years, and it estimated that energy R&D in the private sector would amount to about an equal sum, so that during

this period the overall energy R&D budget for the Nation would be over $22,000,000,000.

Wherein do the NEF recommendations differ from what the Government had been doing in energy R&D? There are two differences: philosophic and budgetary. The philosophic difference was that for the first time our entire energy R&D program has been studied coherently and as a whole; all modalities were considered, and an attempt was made to fit them into an overall energy policy. Second, there were essential changes in emphasis and in budget - primarily, a significant increase to $480,000,000 for FY-75 coal research, a large commitment to energy-related basic research in the amount of $300,000,000, and substantial increases for environmental, fusion, and particularly long-range energy possibilities such as geothermal and solar.

Let me expand on the role we see for R&D in Project Independence. The basic strategy for achieving the goals of P. I., however precisely or loosely these are finally set, is three-pronged:

1. Conserve energy by reducing its growth rate to less than three percent per year.

2. Produce more domestic oil and gas.

3. Gradually shift from our dependence on oil and gas, which we believe will always be in short supply, to greater dependence on coal and uranium which, at least in principle, are more abundant than are oil and gas.

In briefest terms, then, our short-term goals for R&D are to help achieve self-sufficiency by efficient energy use, by extending our domestic

sources, and by creating the technology necessary to shift from scarce sources to abundant ones.

For the long range, say the period after 1985, we see two basic aims of our energy R&D. First, we recognize that doing without cheap foreign oil imposes on our country additional costs: economic, environmental, and social. Thus, the first major goal of our long-range energy research and development is to minimize these economic, social, and environmental consequences of the U. S. commitment to Project Independence.

But beyond P. I., there are those very long-term matters that will ultimately affect the whole structure of our energy system and possibly therefore our social structure. Here we are faced with great uncertainties, such as: on which of the long-range energy modalities can we count and which will forever remain dreams? Thus, the second long-term aim of our energy R&D must be to achieve a rational long-term energy system, and to learn enough about the various long-term modalities to enable us, as quickly as possible, to estimate the relative costs of major energy sources and energy utilization options.

It would be quite impossible to describe in detail the elements of our $11,000,000,000 five-year energy R&D program. Rather, I shall speak of a few elements of the program that seem to me to deserve special attention.

First, there is conservation which turns up as the single most important element in every energy scenario for the future. But conservation is an elusive thing; it involves many decisions made by many people - for example, a shift to smaller, more efficient cars, as well as development of better ways of utilizing energy, say in industrial processes. A

basic question, which strongly pervades much of our energy R&D policy, is whether mechanisms of the marketplace will be adequate to bring about ample conservation. No one knows the answer to this question, nor am I certain that any of our sciences can truly answer it. But we must estimate as best we can the role of the marketplace and, more generally, the future demand for energy as affected by various important social and economic factors. Thus, I urge that creation of an energy policy community - that is, a community of scholars who think about energy, who develop better models for our energy systems, who predict the future as best one can - is an essential part of the U. S. energy R&D effort. And, indeed, such futurology is being given a more serious place in our R&D program.

But conservation technology is also essential. For example, the average efficiency of the United States utility industry is only about 30 percent because gas turbines are being so widely used. If the average efficiency could be increased to perhaps 50 percent, possibly with topping cycles, we would thereby reduce almost by half our demand for fossil fuel (in this case, mainly coal) for power production.

A second all-pervasive element in our energy R&D program must be the environmental impact of various energy modalities. Any one of our energy modalities could become unavailable if we should discover that it causes hitherto unsuspected health or environmental damage. An alarming example of this is the finding, still somewhat tentative, that acid sulfate emitted by burning various hydrocarbons may be a much more serious hazard than anyone had suspected even six years ago.

How should we go about determining such environmental effects? There are two possible routes: to conduct such research - according to the pattern established by AEC - in close proximity to groups that are developing the new technologies; or to conduct the research as part of other environmental and health research, but separate from the technological development. This first method presumably makes the technologists more sensitive to such issues, but it possibly may lead to an underplaying of these side effects; the second method makes it harder for the technologists to be fully aware of what the side effects are. I am not prepared to say, categorically, which way is better in all cases, but I am inclined to keep the technologists and the environmental health groups as close together as possible. In the present climate of concern over environment, the danger of their not keeping each other honest is clearly less than the danger of their not speaking to each other if they are separate.

The environmental and health issues are likely to be subtle and long-lasting. Some epidemiologic studies on new energy modalities could last many, many years. Therefore, in creating our instrumentalities for dealing with these questions we shall have to create institutions that have the required longevity and stability. This view strikes many as somewhat dangerous and expensive; long-term institutes are often viewed as long-term sinecures; but where epidemiology is concerned, this is the nature of the problem, and I submit there is no way around it.

Turning now to the energy modalities, I see two relatively short-term and two long-term matters that deserve particular attention. In the shortest

term, we are trying to increase our domestic supply of oil and gas. If we are referring to extraction, then we must depend mostly on existing technology. The question, then, tends to be more a matter of encouraging exploration and investment than it is R&D per se. But in the slightly longer range, we shall be trying to extract liquids and gases from coal and from shale; and here I believe we encounter a serious bottleneck. By 1985 we may have to extract 1200×10^6 tons of coal per year, or double the present level of what we are now mining. Do we have the mining technology, let alone the institutional arrangements, to do this in an environmentally acceptable manner? Thus, I count technology for extracting coal as one of the highest priority items in our long list of important energy R&D issues. Achieving a goal of 1.2×10^9 tons annually means that we shall have to open one new deep mine and one new surface mine each month for the next decade! Is this a conceivable goal with our existing mining technology?

What I say about coal mining holds, to a degree, for shale oil and uranium. With shale oil we ought to be learning as quickly as we can just how much of the 1800×10^9 barrels of oil in the western deposits we can depend on - particularly whether in-situ methods will be successful - and in the case of uranium whether we can by 1985 increase our output from the present 14,000 tons annually to the 70,000 tons projected for that time. It seems odd that mining which was the original technology (De Re Metallica, written in the sixteenth century, was the first modern book on technology) would appear to be the prime technological bottleneck to our achieving a goal of energy self-sufficiency; but perhaps this is

not surprising since so much of the extractive industry has been conducted by small miners who have always shown great ingenuity, but who have lacked the resources to exploit possibilities afforded by the latest technologies.

I shall close with a few remarks about the long-range modalities - solar, geothermal, fusion, fission breeders - upon which our very long-range energy system undoubtedly hinges, but which can have relatively little impact on the short-term aims of Project Independence. As I have explained, it is essential that we know what these options offer since choices that we make now will obviously affect our long-range energy system and also our social system.

The primary questions regarding each modality are: is it technically possible? Will it be socially acceptable? Fusion poses the largest question of feasibility; despite great advances in recent years, the scientific feasibility of fusion has yet to be demonstrated. As prudent custodians of our energy future, to quote Palmer Putnam, we cannot depend on fusion; but we must determine whether it is feasible. To this end, we are planning to spend about $1,000,000,000 over the next five years. Geothermal energy is surely feasible in some embodiments; but what about hot dry rock? Unless hot dry rock is feasible, geothermal is a relatively small energy source. We shall make a concerted effort, therefore, to obtain an answer to this question over the next five years.

This leaves the fission breeder and solar electricity, both of which are technically feasible. But with solar (and here I include solar's children - wind, waves, ocean thermal gradients, bioconversion), we hardly know what it will cost, and with the fission breeder we are rightly concerned

about the long-term social commitment it imposes. We must begin at once to ascertain the real potential of solar electricity (solar heating is I believe being pursued on an adequate scale); and we must resolve any nagging questions that still beset the fission breeder. Of these latter, I consider siting to be one of the more troublesome and one of the more important issues.

Developments in energy storage and energy transmission should open new possibilities for siting fission breeders and their supporting systems in ways that are socially and environmentally acceptable.

Setting R&D priorities in energy, as with setting of priorities in science generally, is complex; and, even with the most able analysis, it must always involve large elements of risk, uncertainty, and even luck. I trust this discussion has provided some insight as to how we in the Office of Energy Research and Development of FEO are approaching this tough, but immensely important, matter of establishing R&D priorities. I would strongly encourage the energy research community represented by this audience to cooperate with the Government in helping to establish these priorities: obviously, we shall need the most skilled and enlightened assistance we can obtain.

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