INTERNATIONAL ISSUES IN ENERGY R & D POLICY

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Energy Laboratory Working Paper No. 75-006WP
August 22, 1975

The current sense of urgency in American efforts to create new technological options for energy production and utilization is largely the result of instabilities and past disruptions in the international oil market. Moreover, the character and magnitude of U.S. energy R & D efforts can be expected to have significant effects on this market and on other aspects of international relations. Nevertheless, scant attention is given in ERDA-48, A National Plan for Energy Research, Development and Demonstration, either to the international implications of the proposed program or to questioning the assumptions that shape its scope and form. The discussion is almost totally devoted to national policy goals and associated technical sub-goals, to the study of alternative patterns of technical development, and to the setting of priorities for R & D expenditures.

In this paper we identify and briefly discuss some of the foreign policy and other international issues that are implicit to the ERDA plan. We do not attempt to settle or even to analyze in any detail the issues and questions that we raise. Our hope is that a brief catalogue of these issues will prove useful to those reviewing the current plan and serve as a guide to further analysis. We divide the issues into three rough categories.

Quite naturally the ERDA analysis begins by setting out five national policy goals that are derived from the authorizing legislation. These goals are heavily concerned with national security, the independence of national policy from foreign influence and world stability as well as

economic growth and efficiency and environmental quality. The Plan may be viewed as a strategy for achieving these national policy goals and as such deserves close attention and evaluation. But anyone who, like the Congress, takes the broadest view of our policy in the energy area should also question the (frequently unstated) assumptions underlying both these goals and the choice of implementation strategies. We begin by identifying and raising questions about a number of these important underlying assumptions concerning the international system and America's role in it.

Next there are international implications of the R & D activities themselves, including the relative priorities among various possible R & D projects and the ultimate disposition of the knowledge and experience that will be gained. We raise questions related to the realization of returns on U.S. investment in energy R & D, nuclear security and proliferation, environmental protection and the energy R & D needs of other countries.

Finally, we raise a special set of problems related to U.S. attempts to speed the commercialization of substitute fuel technologies. The main issue here is the worry that certain policies designed to speed commercialization could have the side effect of locking the U.S. economy into high energy prices even in a circumstance where world prices might fall. Such an event would have unfavorable consequences for the international competitiveness of energy-intensive U.S. industries.

1. Questioning the Assumptions of U.S. Energy Policy

1.1 Independence from Foreign Energy Sources

We recognize that in writing its plan for energy research, development, and demonstration ERDA was mandated to reflect rather than question or evaluate the assumptions embodied in Project Independence. Yet those assumptions can and indeed should be critically reviewed because the scope, structure, and urgency of ERDA's plan is largely a result of accepting those assumptions.

A fundamental presumption of Project Independence is that the American national interest requires the levelling off and ultimate decrease of oil imports. The reason for this, as stated in Chapter 1 of ERDA's Plan, is that "Dependence on imports makes the United States vulnerable to undesirable external influences on U.S. foreign and domestic policy. Foreign powers can threaten lifestyles and economic stability by curtailing the supply of petroleum or affecting arbitrary and sudden price changes." The vulnerability to increases in world oil prices has been well demonstrated since 1973 and the imposition that year of a boycott against the United States (along with a curtailment of oil production) by the Organization of Arab Petroleum Exporting Countries (OAPEC) has heightened concern about the impact of supply curtailments. The ERDA Plan suggests that if oil imports were permitted to continue rising, the United States would become increasingly vulnerable to external coercion by oil exporting states in the conduct of its foreign policy. The proposed solution is the R & D program presented.

This formulation of the problem and the appropriateness of the proposed solution may be questioned. Even if the United States were to become largely or totally independent of foreign energy supplies, it seems unlikely that its major allies, Japan and Western Europe, could or would want to achieve a similar position. Indeed, although these countries are also moving somewhat,

particularly in the nuclear area, to reduce their own dependence on overseas oil, they seem somehow to have come to terms with that dependence. They do, of course, have neither the range of options nor the extent of global interests that the United States has and therefore the circumstances are not directly comparable. Nonetheless, one must ask whether the United States will have gained very much if, after spending large amounts of money to develop its domestic energy supplies, it finds its major allies are still highly dependent on imported oil. One of the lessons of 1973 is that the United States is vulnerable not only through its own supplies of oil but also through coercion that may be exerted on its allies. Under the assumption that America's alliance relationships and commitments will remain as important in the future as they have been in the past, the country must ask to what extent it is worth a large expenditure to gain its own independence in energy supplies while its allies remain highly dependent.

From a somewhat more parochial U.S. perspective, the existence of a security problem for this country in isolation can be recognized without necessarily agreeing that curtailing oil imports or a vigorous energy R & D program oriented to that goal is required. In another age, the United States would have contemplated guaranteeing its supply of oil by force of arms. Today this approach appears to most Americans to be much less feasible or morally unacceptable. But just as force in the past would have been viewed not as a substitute but as an extension of international diplomacy, the same should be true in present circumstances of technological initiatives. Since the interruption of the flow of oil involves significant costs and risks for oil producing nations, it cannot be expected to happen for no reason. Rather than simply to try to insulate itself from the affects of future boycotts, the United States could attempt to ameliorate by diplomatic

and other means the underlying causes of disruptions of the international oil market. Indeed, this is one of the purposes of American mediation in the Arab-Israel dispute. A peaceful resolution there would go quite far in reducing the incentives for future boycotts, and thereby in lessening the apparent threat to the security of American oil imports. It might also therefore decrease the urgency to invest in high-cost energy R & D options. A U.S. energy R & D program may be a useful adjunct to diplomatic activity and a hedge against its failure, but in any case it should be sized and structured in ways that compliment, support, and extent the nation's diplomatic activity.

A similar observation can be made in the nuclear area. Just as in the case of liquid hydrocarbons, ERDA's proposals for nuclear R & D is based on the assumption that the United States should not become dependent on imported energy supplies, in this case uranium. The major reason for urgency in the liquid metal fast breeder program is the stated need to increase the energy extractable from domestic uranium. There is, however, no analysis of world uranium supplies or the world uranium market and no discussion of whether some combination of diplomacy and financial investment could make large amounts of uranium reliably available to the United States and its allies. Instead, the analysis assumes without supporting justification, that world supplies of uranium are either too small to meet the demand using nuclear converter technology or likely to become inaccessible.

Although not explicitly recognized in ERDA-48, the energy R & D Plan itself can and should be seen as a form of diplomacy. The very fact that the United States is engaged in an R & D program, a stated purpose of which is to increase the independence of its foreign policy, will alter the psychological climate on a variety of world issues and thereby influence the

relationships among nations. Without such a program it might be much more difficult for the United States to exert leadership among oil consuming nations and to encourage its allied to reduce their own vulnerability to imported oil supplies. Similarly, OAPEC might perceive their leverage over American policy to be decreased if the United States seems to be moving by a concerted effort toward decreasing its oil imports. The R & D program might therefore serve as a deterrent against future boycotts as much as a hedge against their imposition.

World perceptions of the United States as a great power will be influenced by both the reality of and American attitudes towards its vulnerability to external coercion through the oil market. The R & D program can be viewed therefore as an important symbol of U.S. leadership and power and a signal that these will not be allowed to erode. This is comparable to the role of the U.S. space program through the 1960's. To understand the importance of this symbolism one need only look at current world perceptions of Japan and compare these to perceptions before its vulnerability was demonstrated during the oil production cutbacks of 1973. To the extent that the R & D program does indeed structure perceptions of other nations concerning the United States, it will contribute to maintaining American leadership, interests, and alliance relationships around the world. A particularly important case is that of Isreal who will probably be more willing to rely on American mediation and perhaps American guarantees as it negotiates with the Arabs if it perceives that the United States is not exceeding vulnerable to Arab coercion via the oil market.

1.2 The Price of Oil

Another assumption of Project Independence is that the price of oil

will stay very high and perhaps increase in coming years. While this may very well be true, it may also be false and must remain one of the major uncertainties under which U.S. energy policy (including the R & D program) must operate. There are important implications of this uncertainty. Any R & D program should maintain a flexible management structure in order to adjust priorities as intrinsic uncertainties become resolved. Maintaining flexibility becomes even more critical in the face of such major external and uncontrollable uncertainties as exist in this case.

Another issue that deserves attention is the possible effect of U.S. energy R and D on the world oil price itself. The ERDA plan is careful not to argue that its efforts would have an effect on world price; indeed the assumption of a high international oil price holds throughout the discussion. But many people believe that the development of alternative technologies, and their commercialization in the U.S., will have the effect of lowering or putting a ceiling on the world oil price, and therefore this is an issue that will arise in reviewing this plan and in debates over priorities and programs.

Usually this argument is stated in the following terms: Since R & D opens up new options for supply and establishes the costs of replacements to oil and gas, it sets an effective ceiling on the price that can be charged by the oil cartel. Or it may be argued that the R & D program will actually have an effect on the net demand of the United States for world oil (through increased domestic supply and reduced domestic demand) and that this shifting of supply and demand curves will change net demand for cartel oil in such a way that the cartel leaders will be led to lower the price. As one looks at an energy R & D program, and the variuos subsidy and protection activities that may be designed to encourage adoption of

developments resulting from such a program, it would be very useful to have a clear idea as to whether the program is actually likely to have such an effect on world price.

Unfortunately, from the point of view of economic logic and what we know about cartel behavior, such a program is likely to have little effect on world price and could even lead to higher prices on international oil. However, there are some psychological and political effects of such a large scale program that could have some dampening effect on the ability of the cartel to raise prices. There are three aspects that deserve attention: the effect of the program on the net demand faced by the cartel (and thus on its pricing policy), the effect of the R & D program as a signal for pricing by the cartel, and the effect of the R & D program as a signal of the United States' determination and leadership in the energy field.

Supply and Demand Effects. One of the pervasive notions in the debate over energy policy is that if the United States lowers its demand for world energy, then the price of that energy will come down--simply by the normal laws of supply and demand. This is an argument carried over from competitive markets where a downward shift in the demand curve would be expected to lower price. But the logic cannot be applied to a circumstance where price is not set by competitive forces. Under a monopoly or some form of international commodity cartel, small shifts in the net demand faced by the cartel may lead to lower prices; they may just as well lead to higher prices.

In order to demonstrate the condition of the cartel at present, Table 1 shows the current production by OPEC members along with an estimate of the productive capacity of these countries. "Productive capacity" refers to the ability of the country to bring oil out of the ground and deliver it to the international market. The table shows potential supply (say

deliverable within 60-90 days) of around 36-38 million barrels per day, and an actual current production of 26-28 million barrels per day. The current excess capacity or "overhang" in the cartel is thus in the neighborhood of 10 million barrels per day, or roughly 30% of OPEC productive capacity. In the months since Table 1 was calculated, the excess has grown.

Thus the cartel has been able to maintain price under conditions of a large excess supply. How long the cartel will be able to function under these excess supply conditions, or whether the excess will grow or diminish over time, is not known. What is clear is that it is unlikely that shifts in the demand from the U.S., causing only a minor change in the total demand faced by the cartel, are going to have an effect on the ability of the cartel to maintain the discipline necessary to prevent price shaving or cartel breakdown.

Moreover, even if the demand shift were perceptible by the cartel, the response might be to raise price rather than lower it. If one assumes the cartel members have some needs for current revenue, and for the building up of international reserves, then if demand should slacken they can best maintain their financial position by raising price. Their ability to do this is a function of the internal discipline of the cartel and the pressures created within the cartel by slackening demand and excess capacity. Their success at this task is a function of many elements, and the effect of changes in U.S. demand of a million or two million or three million barrels a day is but a minor factor.

In short, therefore, though the R & D program and other efforts to lower U.S. demand may be expected to have a desirable effect on our net dependence or vulnerability to the world oil market and on our balance of payments, it is not reasonable to argue that this program will have a

Table 1. Reserves, Production, and Capacity for Key Exporters

(thousand barrels per day except as noted)

Group, Country	Reserves (billion barrels)	Production		Net Capacity[a] end-1974	Excess Capacity	
		Dec. 1974	Jan. 1975		Dec. 1974	Jan. 1975
OPEC[b]	489.1[c]	28,474[c]	27,055[c]	37,627[c]	9,153[c]	10,572[c]
Iran	66.0	5,915	5,543	6,522	607	979
Iraq	35.0	2,184	2,072	2,198	14	126
Kuwait[d]	81.4	2,315	2,031	3,393	1,078	1,362
Saudi Arabia[d]	173.1	8,047	7,890	11,335	3,288	3,445
UAE, et. al.[e]	45.9	2,047	1,617	3,000	953	1,383
Algeria	7.7	800	800	1,147	347	347
Libya	26.6	975	970	2,447	1,472	1,477
Nigeria	20.9	2,063	1,984	2,374	311	390
Indonesia	15.0	1,241	1,345	1,667	426	322
Ecuador	2.5	55	55	319	264	264
Venezuela	15.0	2,832	2,748	3,225	393	477
(Canada)	9.4	(1,468)*	(1,700)**	(1,717)	(249)	(17)

[a]After allowance for decline

[b]OPEC includes Saudi Arabia, Iran, Kuwait, Iraq, Union of Arab Emirates (UAE), Nigeria, Libya, Algeria, Gabon, Indonesia, Venezuela, and Ecuador. It does not include Canada.

[c]Sum of countries (not including Canada) listed above. All production figures from Petroleum Intelligence Weekly, 3/3/75, p. 10; all reserves (1/1/75) from Oil and Gas Journal.

[d]Including Neutral Zone

[3]UAE, et. al., includes Abu Dhabi, Dubai, Sharjah, Qatar and Oman for reserves, but only Abu Dhabi, Qatar, and Other UAE for production.

*From November, 1974 data in OGJ, 2/24/75, p. 110.

**From December, 1974 data in OGJ, 2/24/75, p. 110.

predictable effect on world price through the normal forces of supply and demand.

Price Signals. Another argument about R & D is that such programs will establish the costs of the alternatives to natural petroleum (say, synthetic fuels from coal), and that this information then sets a limit to the price that the cartel should rationally charge. That is, if it is established that synthetic oil can be had at $7 a barrel, then the cartel would be irrational to charge $10 or $12 per barrel and thereby call forth a massive investment in facilities to produce such synthetic substitutes. The prospect, it is argued, is that such a technology could not only serve all the demands of the United States, but that the United States could become a net exporter (or other countries could adopt the technology) and the cartel would have set in force (by its pricing policy) the development of alternatives that could have a very large effect on net demand for their exports.

There is no doubt that the price of possible substitutes for oil has an effect as a signal to the cartel. Whether the firm establishment of cost figures is helpful in leading the cartel to lower prices from current levels is quite another question. If one were to expect that R & D programs were likely to establish synthetic substitutes for oil at prices in the range of $7-10 per barrel, then an R & D program might have an important effect in signaling to the cartel that in setting too high a price it runs the risk of killing a large portion of its market. But it now appears that the costs of substitutes will run in a range above two times this amount. The signal given by the research and development on synthetic fuels, and by the construction of demonstration plants in this area, is likely to be that the price now being charged by the cartel is nowhere near the likely real cost of synthetic substitutes. By reducing uncertainty on this score the R & D program could actually have the effect of leading to

increases in world price.

This is not an argument against research and development. It simply shows that the justification for the program must lie in the opening of new options and in raising the possibilities of a lowered dependence on imported oil, not in the likely effect on price.

Signal of Determination and Leadership. To the extent that a strong energy R & D program is a signal to the world, including the OPEC cartel, of American determination to do something about energy dependence and to exercise leadership in the energy field, it could have some influence over the international price of oil. Since the price-setting activities of the cartel are partially political in nature (though, as argued above, the economic incentives are strong determinants of the cartel's behavior), such a demonstration of leadership may have some dampening effect on the willingness of the cartel to push very hard in the price area. Simply by making a commitment to carry out strong program in the R & D field, the U.S. signals intentions and thereby strengthens its bargaining position in what is to some extent a political battle over the price of this critical commodity.

An example of this type of effect on the opposite side of the fence is the research now being initiated on solar energy by Iran and Saudi Arabia. By any economic calculus it is totally irrational for Saudi Arabia to be expending her resources on solar energy at this time. The cost to the country of using the oil so plentifully found in the ground is near zero at present, for the use of a barrel of that oil today involves an opportunity cost of not having that barrel 50 or more years in the future. The present value of that lost option is vanishingly small, so it is irrational from an economic point of view to expend resources on solar energy R and D. Saudi Arabia can certainly afford to wait on the results

of solar R & D efforts in the U.S. and other countries.

On the other hand, since one of the primary arguments of the oil cartel is that oil is running out and that it must be saved for specialized uses, the degree of commitment of the cartel to this argument, and therefore the strength of their bargaining position in discussion of world oil prices, is to some extent strengthened by their willingness to commit resources to develop alternative sources of energy for themselves. In short, the R & D program becomes a bargaining ploy in international negotiations even though the costs of the resulting technologies may be completely out of line with the likely costs, or even the monopoly price, of conventional petroleum.

Now it should be re-emphasized that the foregoing discussion is not intended as a criticism of ERDA for not having addressed more fully the issues raised here. ERDA was given a set of goals relating to energy independence, economic efficiency, and environmental quality; and the agency should not be responsible for factoring in these broader considerations.

These wider issues are of interest, however, to one who wishes to evaluate the scope and structure of the ERDA energy R & D plan as an element of overall national energy policy and foreign policy. The energy R and D program will be expensive both in dollars and in other scarce resources. The extent to which it should take priority over other social needs depends on judgments about the correctness of the underlying assumptions of Project Independence, and the extent to which the R and D program can ameliorate the problems identified.

2. International Implications of the R & D Program Itself

2.1 Realizing the Returns from Public R & D Expenditure

There may be large financial gains to be had from the exploitation of the results of energy R & D expenditure by the U.S. government as a result of programs carried out by ERDA, by contractors financed by ERDA, or by other federal agencies. New technologies are going to be developed, and some portions of these technologies are going to be commercially feasible. The new technical developments will open new industrial markets which will be exploited by U.S. firms employing U.S. labor, or by firms operating in other industrial countries. Several issues arise on this score:

- is U.S. industry going to be able to capture the new markets that may be based on these U.S. sponsored R & D programs?

- are there policy measures that can be taken to help insure that U.S. industry does gain an advantage in these markets? Are there policies extant that operate to the disfavor of U.S. industry in this regard?

- is it in the national interest to <u>try</u> to take measures to give U.S. industries an edge in the exploitation of new technologies? Are there potential diplomatic gains, or pitfalls, in the way we handle this issue?

There are examples in the past of situations where U.S. federal R & D has had a significant effect on the emergence of U.S. industry as a leader in international markets. Research on aircraft technology, carried out largely for defense reasons, has had a strong effect on the competitive position of the U.S. aircraft industry abroad. Research on semi-conducting materials carried out as part of the defense and space programs has had a

significant effect in opening up new markets both in the U.S. and abroad for an expanded electronics industry. And, of course, the position of U.S. industry as an international arms supplier has benefitted from the technical developments resulting from federally funded R & D.

In the energy area, the clearest example is the AEC program to develop commercial power reactors. Partially as a result of this federal expenditure, General Electric and Westinghouse are, at present, the world leaders in this technology. The U.S. economy benefits as a result. As in the case of certain defense industries, the existence of a security classification system probably hindered the attempts of foreign industries to catch up with the U.S. technical lead in this area.

On the other hand, recent trends in the nuclear reactor industry indicate that the gains to the U.S. economy may be short lived. Since G.E. and Westinghouse are international corporations, they participate in the nuclear construction industries in several foreign countries. It is quite possible for a Westinghouse reactor to be installed in a Latin American country by a European firm (which Westinghouse has licensed and may partly own), with the great part of the actual manufacturing (i.e., the value added) taking place outside the U.S. In the process, of course, the skills and knowledge are being transferred abroad.

No doubt the precise details of this kind of deal are influenced by the policies of the governments involved as well as by the commercial interests of the (U.S. owned) corporation holding the technology, and it is true that these contracts vary tremendously in their net economic value to the U.S. Nonetheless, the issue is raised about the diffusion of technology to Europe, Japan and the Soviet Union: to what extent should the

U.S. encourage the rapid diffusion of technical results and know-how to other countries (and thus to competitors of U.S. industry), and to what extent should the U.S. adopt a protective policy and try to insure that significant benefits from construction and manufacturing of new technical devices accrue to American industries in their U.S. plants?

Now it can be argued that there is very little the government can do to control this process. Many new technologies, of the type that the ERDA may encourage, appear to go through a more or less predictable "life cycle": They are developed in the economies that have the technical expertise to carry out the R & D and initial industrial development (in many cases the U.S. has filled this role). In the early stages of exploitation, when markets are small and profit rates may be high, the new industry is likely to be dominated by the country that made the original investment in R & D. As demand grows and the technology "matures", however, profit rates per unit fall and cost-cutting becomes important. In this stage of the "cycle" the normal forces of international comparative advantage take hold, and the industry will gravitate to the countries that can produce at least cost. Multi-national corporations probably serve as a lubricant in this process.

To the extent that new technical developments fit this "life cycle" model, and this is a subject of some debate, the ability of governments to control who reaps the benefits of their own expenditure is limited, except in the early stages of exploitation. Moreover, the ability of the U.S. to restrain the flow of technology abroad is limited by international agreements, treaties, and the provisions of international organizations such as the International Energy Agency (IEA).

Aside from these feasibility questions, there may also be reasons for the United States to forego willingly some of the economic benefit of its energy R & D program and encourage the diffusion of technology to governments or companies of other countries. As already mentioned, the potential for coercion of the United States by oil producing states derives not only from American dependence on foreign oil, but also from the dependence of America's allies. By permitting free access to the results of its R & D, the United States might stimulate its allies to reduce their own dependence on oil imports. Similarly, wide dissemination of technology might contribute to the exercise of American leadership in world energy matters, enhance its international prestige and encourage solidarity of oil consuming nations through the International Energy Agency.

These possible benefits of foregoing economic advantage must be weighed against the value of the economic benefits foregone, before decisions can be made concerning government policy toward international diffusion of energy-related technology. We do not prejudge the outcome of such analysis. It is clear, however, that the level of expenditure and potential economic gain in international markets demands that the issues be studied. There are opportunities for encouraging or discouraging, for facilitating or inhibiting domestic companies from obtaining advantages in international trade in commercial technologies developed with the aid of federal R & D funds. Some of the possible instruments are: policies of ERDA and other government agencies regarding domestic and international patents; participation by foreign firms in ERDA R & D, and demonstration projects; policy regarding security classification of certain results, particularly in the nuclear field; participation in international cooperative ventures; and practices with regard to publication and dissemination of research results. These deserve to be reviewed

in the light of the types of market opportunities that may open up and other foreign policy goals.

2.2 Nuclear Issues

The ERDA plan contains a large component of research on nuclear technology, and much analysis of the implications of potential developments in this area. Of all the individual R & D areas in which the U.S. is involved, the nuclear field has the most important international implications.

Enrichment Services. In recent years the availability of uranium enrichment services has become an important international issues. With the rapid growth (and expectations for further growth) in the commercial nuclear industry, the demand for enrichment services has increased markedly and will continue to do so for the foreseeable future. The fact that U.S. enrichment capacity for future deliveries is now fully committed, coupled with recent changes in American contract terms and regulatory decisions that have delayed shipments, has driven traditional American customers in Europe to other suppliers. In the short run they have bought enrichment services from the Soviet Union. For the longer run they have begun to build their own enrichment facilities (though the planned capacity of both the planned European facilities, Eurodif 1 and Urenco, are reported to be completely subscribed.)

The loss of this business to other vendors is largely a matter of trade and commerce, but the reliance of American allies on the Soviet Union for enrichment purposes raises important alliance and security questions as well. The lack of available and reliable enrichment services in the United States also stimulates other countries, probably including Brazil, to seek to develop or buy their own enrichment facilities. Widespread diffusion of this technology would probably make the prevention of nuclear weapon proliferation

more difficult. These considerations are relevant to the decisions regarding the timing of and choice of technology for the next major U.S. enrichment facility. The need for additional U.S. enrichment capacity is evident enough from looking merely at domestic demand projections, but from a purely domestic point of view one might be willing to delay construction of facilities using gaseous diffusion technology in the hope and expectation that centrifuge or laser enrichment would soon be proven technically and economically preferable. When the international stakes are considered, however, the argument that new gaseous diffusion facilities should be built immediately as a hedge against failure of the other technologies appears more persuasive.

Proliferation. The nuclear part of the ERDA R & D plan raises important national security issues related to nuclear proliferation. For example, the high temperature gas reactor is considered to be a program of some urgency, but no mention is made of its use of weapons-grade uranium in the fuel cycle and the implications of the introduction of such a fuel cycle for nuclear proliferation. Similarly, in the discussion of plutonium recycle in the light water reactor fuel cycle, and of the liquid metal fast breeder, very little attention is paid to the implications (in this case environmental as well as security) of large amounts of plutonium moving in international commerce.

It is true that the issue of plutonium recycle is currently under review by the Nuclear Regulatory Commission and that the environmental impact statement for the LMFBR of necessity deals with these questions; but they should nonetheless be reflected in any overall setting of priorities for energy R & D. While it can be argued that regardless of what the United States decides to do with respect to plutonium, it will probably be in common use in the rest of the world anyway, it is true that decisions made by the United States can influence those being made in other countries.

Also implied in the ERDA plan is a positive attitude toward the expansion of nuclear power in many countries around the world. While there may be many advantages in doing so, these must be weighed against the potential disadvantages of making nuclear materials more accessable to countries that may wish to develop nuclear weapons. Much more thought and discussion is required concerning precisely what sorts of equipment and technology should be transferred to other countries and under what safeguards. In addition to its national interest, the United States has obligations in

this area under the Non Proliferation Treaty.

For example, the United States might (or perhaps should) insist that all countries to whom it exports enriched uranium or other nuclear facilities must return to the United States the spent fuel removed from the reactors. The purpose of this would be to decrease the possiblity of other countries recovering the weapons-grade plutonium from the spent fuel rod and using it for nuclear weapons production. The problem is that the United States would thereby put itself in the position of having to reprocess other countries' spent fuel or provide for its long-term storage. The reprocessing industry in this country is now in disarray, without any plants in operation, and any additional demand would simply add to the problems. Similarly, there are no facilities for medium or long-term storage of spent fuel in the United States today. With the current and the foreseeable backlog of domesticly-generated spent fuel rods an overseas increment would be less than welcome.

An alternative solution might involve some international organization taking on this task, and perhaps other stages in the fuel cycle. This prospect, of course, raises a host of new issues that should be explored.

Peaceful Nuclear Explosives. The absence of any discussion in the ERDA plan of peaceful nuclear explosives (PNE) as a tool for energy production is notable. This may be a result of Congressional prohibition against spending money on PNE field research, or it may be a reflection of recent assessments of PNEs that seriously question their usefulness. Whatever ERDA does in the PNE area, whether it be support or neglect of such research, will have implications for the programs of other countries, however. To the extent that the United States and other nuclear powers suggest, by both

statement and budgetary support, that PNE research is likely to be fruitful, other countries will be encouraged to keep open a PNE option for themselves, either for purposes of resource development or as a cover for nuclear weapons development.

2.3 Environmental Problems

One of the ways that nations interact with one another is by sharing their pollution through the airways and waterways of the world. This is a growing problem as energy production increases worldwide, and there are several particular environmental probems that appear to be of continuing concern in U.S. foreign relations; they need to be kept in mind when evaluating the ERDA program.

Water Resources. The U.S. has a long history of conflict with Mexico over the use of the Colorado River. For many years the conflict was based on U.S. agricultural uses. Now, with the prospect of the further exploitation of Colorado River waters to support expansion of the coal industry, this conflict can be expected to be excaberated. A similar issue may arise with Canada to the extent that power plants or other energy-related construction is situated on lakes or rivers that form or flow across the Canadian-American border.

Sulfur. This is not so much a problem for the United States because of its relative isolation of its industrial centers from other major industrial countries except Canada. But in other areas in the world the transfer of sulfur pollutants through normal climatalogical processes is a signigicant international issue. To the extent that air pollutants in general are transmitted aroung the world, this is an aspect of the international side of research on energy technology which deserves attention.

Oil Spills. Current trade in world oil is large and it can be expected to stay at a high level over many years to come. All nations are susceptible to pollution from accidents occurring to ships of other nations, and therefore the general technology of oil transportation, research and development regarding such transportation, and the regulations that influence it are all matters of interest in international relations.

Global Climatological Effects of Energy Consumption. Looking more broadly, and in a longer-term framework, there is concern in some quarters that energy utilization by the highly developed countries is having an unfavorable effect on the worldwide balance of carbon dioxide, nitrous oxides and particulates, ozone, and on the heat balance of the world itself. These global effects in the long run are not well understood, and research on them would be an aspect of the concerns of ERDA from that standpoint of international relations, even though the actual research might reside in other agencies such as NOAA, NASA, or DOT.

2.4 R & D for the Problems of Other Countries

It is apparent that the bulk of the ERDA effort is directed to the particular technological needs of the United States. The supply options are geared to U.S. conditions in terms of the technical and natural resources available and the magnitudes of the energy supplies needed. The conservation and utilization technologies seem to be oriented to the energy consumption patterns of this country as well.

To the extent that U.S. policy interests are influenced by overall world demand and supply patterns, however, one may ask if the ERDA activity should be concerned for research and development relevant to other countries,

but not so directly applicable to the United States. The clearest example in this area is the special needs of less-developed countries who do not need (or cannot afford) large-scale, capital-intensive, highly complex technical devices for solving their energy problems. They can neither finance nor can they operate such large-scale facilities without an unacceptable drain on limited capital and human resources. There is need for small-scale technology which takes advantage of traditional energy resources such as wood, agricultural waste, and dung, and which makes better use of these traditional resources through technical improvements.

Since the expenditures by ERDA are by far the largest single program of research and development on energy in the world, it might be desirable for some small portion of these funds to be devoted to consideration of the special problems of these countries. At this point, it appears that very little high level research and development talent is being devoted to these issues in the world today. Such involvement by ERDA in technical problems of other countries naturally would be related to the U.S. aid activities in these countries, and the types of technical assistance, education, and technical development which could result from a relatively modest expenditure in terms of the ERDA budget might be significant in terms of its effect on the energy problems of these countries.

3. Commercialization: Subsidy and Protection

As part of its overall responsibility in implementing the R and D plan, ERDA is likely to be deeply involved in programs to encourage the commercialization of new fuels technologies. The way in which this is done may have a significant influence on the price of energy in the U.S. in future years, and on the price of energy in the U.S. relative to that in other industrial countries.

The issue can be seen by taking the synthetic fuels program as an example. If a commitment is made to speedy commercialization of these plants, the same result may be achieved by means of several policy measures; current discussions include various combinations of subsidy and protection of the entity building the plants and varying degrees of direct government involvement. One key dimension on which these proposals differ is the manner in which the developer is protected against down-side price risk. This may be done, for example, by guaranteeing government purchase at some pre-arranged price, or guaranteeing that the market price will not be allowed to fall below some agreed level. The rest of the subsidy arrangement (specific subsidies, loan guarantees, etc.) are then built around this basic understanding about the likely price of product.

To the extent that the policies intended to spur commercialization are directed specifically to particular plants, then the protection of this infant industry need not have an influence on larger price questions. However, if a move is made to protect these newly commercialized sources (which will surely be high-cost) by a policy of guaranteeing some floor to the national oil price (say, by excise taxes or tariffs), then the commercialization program could have a very serious effect on the competitive

position of energy-intensive U.S. industry in international markets. This would happen if a floor was put under domestic prices to protect new sources (much as the oil import policy of the 1960's protected domestic petroleum) and international prices fall below the support level. Alternatively, the same price gap could be created by escalating domestic prices to sustain and increase the growth of the new fuels sector. In this event, great inefficiency might be created in domestic markets if energy prices rose above the real cost (even with a security premium) of imports, and energy intensive export industries would be penalized in world markets.

To date this has not happened in the energy area, and it may not ever happen. But a large-scale R & D program, coupled with a massive attempt at early commercialization, will create a strong interest by a significant sector of American industry (and associated regional and labor interests) in a stable high energy price. The issue of how the U.S. can meet its policy goals and not get locked-in to such a high price strategy merits serious discussion, particularly considering the great uncertainty concerning the future of international oil prices.