D. OVERVIEW ISSUE PAPERS

1. The Nature of the National Energy Policy Goals

ISSUE

The national **energy policy goals stated by ERDA deserve review and clarification.**

SUMMARY

ERDA's R, D&D plan, as outlined in ERDA-48, volume I, states five national energy goals to which energy R, D&D should contribute. Heavy emphasis on self-sufficiency as opposed to environmental concerns will have major consequences in the quality of life and economic well-being of the American people. Similarly, emphasizing self-sufficiency rather than international cooperation will have major impacts on our foreign policy. Emphasis among these goals warrants congressional review. Unless there is agreement between the Administration and the Congress on the priorities given different national energy goals, ERDA's development of an R, D&D program is made more difficult.

A congressional review of the priorities assigned to the five goals takes on particular importance because energy is so central to other policy areas. Other Government agencies will be planning programs ranging from foreign trade to welfare based on their perceptions of these priorities. For these reasons maximum clarificat ion of priorities will be beneficial.

QUESTIONS

1. How were the goals determined?
2. Did representatives of agencies responsible for economics, international affairs, the environment, and natural resources have an opportunity to participate in the formulation of the goals?
3. What is meant by "adequate" employment opportunities (Goal 2)? Will not a particular interpretation of "adequate" have a significant effect on the phasing, size, and nature of an energy R, D&D effort?
4. How does ERDA interpret Goal 1 (independence)? How will ERDA achieve a balance between Goals 1 and 5 (environmental quality)?

BACKGROUND

The possible conflicts that can flow from the emphasis ERDA gives the various goals can be illustrated by looking at how each goal appears to be pursued. Taking each goal in order:

- To maintain the security and policy independence of the Nation.

  ERDA, especially in the systems methodology of ERDA-48, volume I, reduces this goal to a narrow concern for eliminating oil imports, which seriously distorts the meaning of policy independence. ERDA could have read this goal as a mandate to explore with a far greater sense of urgency any of the following, for example:

  — New international institutions for managing fissionable materials and fission products

  — The role of the multinational corporations in global energy policy and the impacts of actual and potential United States, foreign, and international regulations on their conduct

  — The potential impact of international political developments on energy policies

  — The potential role of the United States, as an exporter of fuels (e.g., coal and uranium) and energy technologies (e.g., solar heating) and cooling synthetic fuel processes

  — The potential for cartelization of critical materials other than oil, notably uranium.

- To maintain a strong and healthy economy, providing adequate employment opportunities, and allowing the fulfillment of economic aspirations [especially in the less affluent parts of the population).

  ERDA nowhere interprets this goal explicitly, The goal statement perhaps does not address a critical question concerning energy and society—the degree of coupling of the maintenance of "a strong and healthy economy" with the perpetuation of increases in the quantity of physical resources used in the Nation's economy each year. ERDA's scenarios (including its conservation scenarios) postulate exponential increase in the use of these resources, continuing indefinitely. ERDA could have seized this goal as a mandate to launch a vigorous socioeconomic research program to gain some understanding of the relationship of economic growth, energy, and the quality of life, and to shed light on the potential viability of low-growth societies.

- To provide for future needs so that lifestyles remain a matter of choice and are not limited by the unavailability of energy.

  From available evidence, ERDA uses this goal as a rationale for emphasizing the period beyond the next decade and concentrating on energy supply rather than energy demand. This goal could readily have been interpreted by ERDA as a mandate to plunge into the short-term problems, where life styles throughout the country are being affected by energy shortages and rapidly rising prices. This goal could also have been interpreted by ERDA as a mandate to proceed rapidly to expand its R, D&D program in order to improve the efficiency by which energy is used, since problems with the availability of energy are as much alleviated by reductions in demand as by expansions in supply. Indeed, if supply and demand are not examined evenhandedly, there is a serious possibility of the misapplication of the Federal R, D&D dollar. Even if an "infinite energy source" were found, the extravagant use of energy to provide and convert materials would create material shortages and environmental problems.

- To contribute to world stability through cooperative international efforts in the energy sphere.

  ERDA appears to interpret this goal narrowly as bilateral and multilateral technical cooperation, such as the research program on magnetohydrodynamics being conducted jointly with the Soviet Union. This goal could have been interpreted as a mandate to launch far more vigorous research efforts to explore, for example:

  — The adverse global environmental effects of energy generating technologies

  — The management of the energy supply technologies which have significant impacts on the ocean (e.g., sea thermal gradient technologies, oil tankers, and offshore nuclear plants)

  — The joint creation of short- and long-term targets for energy conservation among the major energy consumer nations

  — The potentiality of one or more new international institutes to examine energy problems globally

— Alternative approaches to the resolution of the growing energy problems of the less developed nations of the world

— The worldwide economic effects of capital shifts due to petroleum purchases by this country.

- To protect and improve the Nation's environmental quality by assuring that the preservation of land, water, and air resources is given high priority.

  This goal is apparently interpreted by ERDA as a mandate to extend prior research programs on the generation, transport, and health effects of nuclear radiation so as to include the physical environmental impacts associated with fossil and other energy technologies. This goal could have been interpreted as a mandate to cast the net wider still and to grapple with the social concern and community resistance (expressed primarily at the local, State and regional levels) associated with virtually every available energy supply technology; that is, a resistance which focuses on adverse impacts to environmental quality, the chance of damaging accidents, and the possibility that the technologies may hold unanticipated, and unwelcome, surprises. These issues are inseparable from the physical environmental impacts, as far as energy policy is concerned,

It would be unreasonable to expect ERDA to have developed responses along very many of these lines in the short time since its creation. It is reasonable, however, to call attention to the apparent reluctance of ERDA to contemplate any broader construction of the five national goals such as those that are illustrated here. Of course, it is quite legitimate that ERDA undertake research in all those energy-related areas discussed here (and others not discussed here), provided that ERDA assures that the areas are explored elsewhere with adequate intensity.

2. Overall Level of the Federal Budget for Energy R, D&D

ISSUE

The overall level of the Federal budget for energy R, D&D (about $2.3 billion for FY 76) **appears to be an outgrowth of decisions made prior to the Arab oil embargo, and should be re-examined.**

SUMMARY

In theory, the overall Federal budget for energy R, D&D is established by developing a budget need for each component and then summing the components. In practice, however, the development of budgets for each component and the choices among components are greatly influenced by what is perceived to be the limit on the overall scale of the budget. The FY **76** Federal budget for energy R, D&D of **$2.3** billion is largely influenced by decisions taken in **1973** before the Arab oil embargo had committed the United States to a policy of energy independence. ERDA should prepare R, D&D programs for higher overall budget levels (e.g., **$20** or **$30** billion for the 5 years beginning in FY **76).**

QUESTIONS

1. How would ERDA's programs change with a 5-year budget of **$2o** or **$30** billion?
2. How will the inflation rate be factored into the development of future budgets?

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BACKGROUND

The total energy research and development budget for ERDA in FY **76** is approximately $1.8 billion. To this must be added the energy R&D budgets in other Federal agencies, **$540** million, and about **$884** million spent in private industry. The total national energy R&D budget is about **$3. I** billion. It is estimated that the runout costs for the Federal portion of the energy R&D budget amount to about $15 billion for the next 5 years.

The overall Federal energy budget is presumably developed by summing contributions of the various components of the program. However, the general scale of the program is inevitably influenced by the implicit and explicit guidelines as to the size of the overall budget for energy R, D&D. Two such guidelines have had prime influence in scaling our present Federal energy, R, D&D program. First, the December 1973 Dixy Lee Ray Report to the President on energy R, D&D, largely prepared before the oil embargo, was geared to an *$11* billion, 5-year program of energy R, D&D. The other guideline is supplied by the Federal Non-Nuclear Energy R&D Act which specified that the Federal investment ". . may reach or exceed **$2o** billion over the next decade." (Public Law 93-577, Section 2(c), 93d Cong., S. 1283, December 31, 1974).

The proposed Federal energy R&D budget is now within guidelines set forth in the Dixy Lee Ray Report to the President. However, it is by no means clear that this budgetary framework is adequate for the present situation.

3. The International Aspects of ERDA's Plans and Programs

ISSUE

The ERDA Plan does not place sufficient emphasis on international considerations.

SUMMARY

ERDA's mission extends well beyond America's national borders. In the interdependent world of the *1970's* and 1980's, energy independence, economic well-being and environmental quality (the essence of the five national energy goals) cannot be achieved without considering international factors. "Project Independence" with its go-it-alone implications for R, D&D (let alone for national energy policy in general) may well be inconsistent with requirements for developing new energy sources in cooperation or coordination with other countries, particularly in undertaking joint exploration and exploitation of nonnational resources (e. g., the oceans). Moreover, the current proliferation of nuclear facilities in the face of the Nonproliferation Treaty poses difficult technical as well as institutional problems of monitoring, inventories, and control. ERDA identifies these considerations in its Plan (volume I,) but barely recognizes them in its Programs (volume II).

QUESTIONS

1. How does ERDA's new Assistant Administrator for International Affairs plan to approach such issues as energy independence, the need for international coordination of energy, economic and environmental policy, the exploitation of nonnational energy sources, and the new challenges to nonnuclear proliferation?
2. What has been the role of ERDA's overseas staff? Why should such a staff be concentrated in Brussels? Should not ERDA be in close liaison with the International Atomic Energy Agency, the International Institute for Applied Systems Analysis in Vienna, and the International Energy Agency in Paris?
3. What is the division of responsibility in the international energy area between the Department of State and ERDA's international staff?
4. What plans or programs does ERDA contemplate for international research and development in the control and disposal of radioactive waste?

BACKGROUND

ERDA must adjust to a rapidly changing world. Many problems that, until very recently, seemed to fall tidily into "national" or "international" categories now spill over, one into the other. A

national energy policy, like a national food policy or a national growth policy, may have profound implications for world order.

But ERDA's problems in this regard are even more acute than those of many other agencies of the Government. "Energy independence," by definition, assumes an international posture that may be incompatible not only with other important energy objectives, but also with critical nonenergy national goals and America's international role. Moreover, the quest (and the competition) for a nuclear solution to the impending shortage of fossil fuels poses some potential dangers that dwarf most other international problems.

ERDA's predecessor agencies had only a circumscribed responsibility and view of the world. This is a legacy that ERDA must quickly strive to remedy. Its problems in this regard may be complicated because of long established responsibilities for international affairs in the executive branch. These constraints are mirrored in the current R&D plan and program.

The appointment of a new Assistant Administrator for International Programs provides ERDA with a timely opportunity to define its role in the international energy area. Until this new official has had a chance to explore and resolve a host of difficult institutional and substantive questions, it would be premature for ERDA to launch new major research initiatives in the international area. Nonetheless, the Congress may wish to express its interests and concerns with respect to the interpretation of ERDA's responsibilities for the international energy issue.

4. Coordination of Programs Between ERDA and Other Federal Agencies

ISSUE

ERDA's plans for coordination with other Federal energy agencies need to be more fully developed.

SUMMARY

ERDA has been mandated (Public Law 93-577) as the primary agency in energy R, D&D with responsibility to integrate and coordinate national efforts. It is not evident in ERDA's plans whether a comprehensive framework is being established to permit ERDA to perform this role adequately. Two types of multiagency research efforts exist where coordination is required. In the first, several agencies undertake different R&D programs aimed at one energy technology. An example are the three different approaches to coal cleanup by ERDA, Environmental Protection Agency, and Department of the Interior. Without a formal structure to bring together these diverse efforts, much waste can ensue with no assurance that the technology will be effectively developed. In the second case, different agencies are concerned with separate elements, such as regulatory, economic, and technological, of a given energy technology. The lack of effective coordination could lead to development of policy which could hinder introduction of technologies developed, for example, by ERDA.

QUESTIONS

1. How broadly does ERDA view its role in energy R, D&D? Does ERDA have the responsibility for ensuring that all research needed to help solve the Nation's energy problems (including those that are non-technological) is receiving proper attention in either the Federal Government, local or State governments, or the private sector?

z. What specific management mechanisms, techniques, or coordination controls will ERDA use to integrate and coordinate its activities with other affected Federal agencies?

BACKGROUND

Each task group notes areas where the coordination between ERDA and other Federal agencies is required, and the reader is referred to those reports for more detailed descriptions of problem areas, They can be characterized in brief, however, by the following examples:

. In the 1972 Energy Reorganization Act, the Nuclear Regulatory Commission is required to report to-the Congress on the clustering of nuclear reactors and supporting facilities in "nuclear parks." However, this topic may be vital to the entire future of nuclear energy,

and the ERDA Plan does not indicate how heavily ERDA will be involved with the Nuclear Regulatory Commission in addressing this topic.

- In the energy conservation area, some means of formal management control must be developed to assure coordination of related programs in various Federal agencies and departments (e.g., Federal Energy Administ ration, Environmental Protect ion Agency, Federal Power Commission, Department of Transportation, Department of Commerce, Department of Housing and Urban Development, and U.S. Department of Agriculture) that impact on energy demand. Of critical concern is the relationship between ERDA and the Federal Energy Administration in efforts to coordinate analysis and policy input in R, D&D program design, The lack of a clear statement regarding the way in which the implementation measures managed by the Federal Energy Administration will be integrated with the R, D&D programs of ERDA requires attent ion,
- In the fossil fuel area, a point of concern is the division of responsibility for the clean direct utilization of coal. Precombustion cleanup (e.g., by magnetic desulfurization) is in the scope of the Bureau of Mines; cleanup at the point of combustion (e.g., by fluidized bed combustion) falls within ERDA; postcombustion cleanup (e.g., by stack gas scrubbers) is largely within the Environmental Protection Agency.

The ERDA Plan does not indicate how tradeoff evaluations or a balance among these separate responsibilities and/or alternative approaches are to occur. The criteria used to evaluate each option could vary with the lead agency, and there may be no place where the entire profile of criteria—environmental, economic, institutional, efficiency—is applied across the board to all options. The size and effectiveness of programs devoted to each technology or problem element by different agencies could be quite variable, and there is no guarantee that the overall effort will be properly balanced or that its components will be compatible.

5. Cooperation Between ERDA and State and Local Governments

ISSUE

Success of the ERDA program will depend largely on close and continuous coordination with State and local governments. The ERDA Plan includes neither procedures nor mechanisms for accomplishing this coordination.

SUMMARY

State and local governments are well aware of the Nation's energy problems and are committed to support the programs necessary to meet these problems. Their perception of the Nation's energy problems, however, differ from ERDA's. They are more concerned with local impacts of energy projects, accord more importance to conservation and, most important, feel strongly that they should be included not only in the planning phases of R, D&D programs but also in the implementation phases.

Failure of ERDA to consider properly these viewpoints may well result in unnecessary conflict and delays in program implementation. Thus, it is important for ERDA to expand the Office of Industry and State and Local Government Relations and to provide the local governments regularly with information, such as a listing of all energy R, D&D projects, clear definitions of State and local roles in energy R, D&D, and well defined planning procedures.

QUESTIONS

1. What specific procedures does ERDA project for effecting coordination of its program with State and local governments through the R, D&D process? What is the schedule for their implementation?
2. Does ERDA plan to produce and circulate to State and local governments a listing of program plans to assist states in their own planning processes? When can distribution be expected?
3. Does ERDA plan to conduct or sponsor research projects concerning the potential impacts of its R, D&D program? What will be the scope of such research; by whom will it be conducted; and how will State and local governments be included in research efforts?
4. What plans does ERDA have for supporting and maintaining liaison with multistate organizations interested in regional energy planning? What are the mechanisms involved; who is responsible for coordinating ERDA's efforts; and what will be the scope of the effort in terms of manpower and funds?

BACKGROUND

Although volume I of ERDA-48 states that ERDA recognizes the importance of State and local participation in its energy programs, no mechanisms are specified by which such input into program planning and execution can be accommodated.

The State and local governments are well aware that the primary responsibility for initiating and carrying out large governmental research and development programs resides with the Federal Government and, more specifically, with ERDA. However, they recognize that they, too, have major contributions to make in the translation of these programs into energy-producing facilities. The successful development and implementation of ERDA's energy projects will depend on appropriate water allocation, on reasonable land use regulation, on realistic local taxing policies, on successful manpower training programs, on consistent environmental controls, and ultimately on public acceptance of new technologies and procedures. All of the foregoing are areas in which State and local governments possess valuable experience and expertise, and their cooperation could prove extremely useful to ERDA. However, if these governmental bodies are to lend effective support to the ERDA program, it is imperative that their involvement begin in the early stages of program development.

If, on the other hand, local governments feel that Federal agencies are encroaching on their responsibilities, their opposition can generate delays or even cancellation of important programs. Delays may also occur simply because the States are not kept abreast of energy related decisions, State and local governments may be willing, for example, to provide roads, schools, utilities, and other facilities to support pilot, demonstration, or commercial plants; however, even the planning for such facilities cannot be started until locations and construction schedules are known.

To assure maximum positive participation by State and local governments in its energy programs, ERDA could establish and utilize several practical mechanisms for effective coordination. Examples of such mechanisms are:

- Expanding the Office of Industry and State and Local Government Relations to provide an effective ERDA contact point for non-Federal government bodies, keeping them abreast of ERDA policies and programs, and transmitting their recommendations and concerns to the proper ERDA office.
- Establishing procedures to consider State and local government positions in all program planning activities; e.g., via the National Governors' Conference.
- Keeping State and local governments informed and updated of ongoing and planned energy R, D&D projects.
- Providing for studies to analyze the potential impacts of implementation plans for all R, D&D projects on local areas.
- Encouraging multistate cooperation in energy program planning, by liaison with existing regional organizations.

6. Near-Term Energy Problems

ISSUE

ERDA's Plan gives very little attention to near-term to 1985 energy problems.

SUMMARY

The "first strategic element" in ERDA's Plan is "to ensure adequate energy to meet near-term needs until new energy sources can be brought on line. " ERDA plans to accomplish this through enhanced gas and oil recovery, direct use of coal, more use of nuclear reactors, shifting demand away from petroleum, and increased conservation practices. A review of ERDA's FY 76 budget indicates, however, that only about 5 percent is devoted to solving near-term problems, which does not seem consistent with the stated goals, This deficiency results primarily from the lack of emphasis given to end-use conservation, the lack of attention to nontechnical research needs, and a tendency to focus on large-scale electric supply technologies.

QUESTIONS

1. Does ERDA feel that its Plan gives sufficient attention to the energy problems faced over the near-term (next 10 years)?
2. Three options for dealing with near-term problems not given much attention by ERDA are end-use energy conservation, incremental improvements in existing supply technologies, nontechnological research to identify institutional and social barriers to increasing energy supply or reducing consumption. Does ERDA feel it should increase its efforts in these areas?
3. How will ERDA ensure that proper attention is given to advancing the arts in "low technology" areas?

BACKGROUND

Of a total ERDA energy budget of about $1 billion, the only items relevant to the next decade are energy supplies ($80 million) and end-use conservation (less than $7 million).

ERDA's lack of attention to near-term problems is closely connected with two other issues: (1) too little emphasis on end-use conservation, and (z) inadequate programs of nontechnological research aimed at understanding institutional, social, and regulatory constraints. Serious R, D&D in these areas could be highly productive in the near-term. The reader is referred to chapter V for a more detailed discussion of these deficiencies.

Also related to the lack of priority given near-term problems is ERDA's tendency to focus primarily on large-scale electric power technologies. ERDA's strength in these advanced areas of science and technology (e.g., fusion and breeder reactors] is good and should be extended. However, many potential improvements relate to simple technology, and many of these could have near-term impacts, such as better storm windows; home furnaces; home, commercial, and industrial lighting systems; tires; and **solar water** heaters. Large and sophisticated technologies have inherent appeal, especially to scientists and engineers, but ERDA must be careful to give proper priority to incremental improvements in existing technology.

7. Socioeconomic Research

ISSUE

ERDA's program of R, D&D does not give enough attention to socioeconomic analysis and research in addressing the Nation's energy problems.

SUMMARY

ERDA's program plans, budgetary commitments, and professional staffing do not give adequate attention to social, economic, environmental and behavioral research needs, even though the legislative record makes clear that ERDA is given responsibility beyond technological R, D&D (Public Law 93-577, section 5A). Such research is needed for two reasons: (1) to better understand the relationships of energy and the quality of life, and (2) to identify nontechnological constraints to increased energy supply or reduced energy demand. The nonhardware research programs must be integrally tied to the hardware programs and the results used when evaluating and comparing alternative approaches to "solving the energy problem,"

QUESTIONS

1. How much effort is being devoted by ERDA to socioeconomic research?
2. What research program does ERDA envisage to explore the intimate connection between energy supply and use patterns and the quality of life?
3. How many professionals with social science backgrounds are employed by ERDA?

BACKGROUND

Although legislation gives ERDA broad responsibility beyond technological R, D&D (Public Law 93-577, section 5A), many important energy supply and demand issues have major nontechnological components. In spite of this, ERDA's program plan, budgetary commitments and professional staffing show little emphasis on such problems. If ERDA intends to help solve energy problems through R, D&D rather than merely create new technological options relevant to solving energy problems, it must place more emphasis on social science and other nontechnological issues. The degree and nature of coupling between the condition of the economy and the quantity of resources, especially energy, consumed each year is poorly understood, yet crucial to national energy goals.

Each of the five task group reports explicitly criticizes ERDA's disproportionate emphasis on hardware research and development. These observations emphasize the need for a balanced program, since nontechnical constraints are often the most serious impediments to deployment of a technology. Specifically, the Fossil Fuels Task Group reports that little attention is paid to nontechnical constraints that can seriously delay or altogether block the introduction of new technologies; the Nuclear Task Group concludes that some of the primary obstacles to achieving nuclear goals and objectives are financial and institutional; the Solar Geothermal and Advanced System Task Group reports that major impediments to rapid utilization of geothermal resources are legal and institutional;

the Conservation Task Group states that ERDA-48 does not adequately address the social, political, economic, and environmental problems inherent in the application of energy conservation technologies; and the Environmental Task Group notes that ERDA overemphasizes the engineering aspects of environmental protection,

As one example, consider the case of offshore oil and gas development. Currently, ERDA has no identifiable R, D&D component associated with this particular resource, even though most qualified observers agree that this is one of the few options available for increasing oil and gas fuel supplies in the near-term (by 1985). The hardware associated with offshore development is commercially available, and there are probably adequate incentives for industry to continue to improve the technologies where possible. Thus, there is probably no reason for ERDA to undertake hardware research in this field. On the other hand, there are serious obstacles to expanded offshore development that are related to the environmental impacts—concern about the effects of oil on marine ecosystems and about the onshore socioeconomic effects. Whereas some recent legislation has proposed that coastal states be compensated for adverse impacts produced by offshore development, currently very little is known about how to measure these adverse impacts. If offshore oil and gas development is proceeding at a significant rate, then a greatly expanded research effort is needed to determine its environmental, social, and economic impacts. This research obviously should and could not be done by the industry—it is the responsibility of the Federal Government. Some research of this type is currently being done by the Environmental Protection Agency, National Oceanic and Atmospheric Administration and Office of Technology Assessment, but no such programs currently exist in ERDA.

8. Balance Between Supply Versus Demand R, D&D

ISSUE

ERDA's program overemphasizes energy supply technologies relative to energy consumption.

SUMMARY

The present pattern of energy consumption was developed during an era of constantly decreasing real energy prices, so little emphasis was placed on end-use efficiency. Although there is some recognition of the need for improvement, ERDA's conservation program focuses primarily on the near-term and underestimates its long-term importance. Factors inadequately considered in the relative emphasis on consumption and supply technologies are cost-effectiveness, time to payoff, environmental benefits versus costs, and demand on resources.

QUESTIONS

1. How is ERDA planning to investigate the relative cost-effectiveness of research on energy demand and research on energy supply?
2. Suppose a National goal with respect to energy was specified as follows: "to maintain energy consumption near its current level to the year 2ooo while simultaneously maintaining a strong and healthy economy." What R, D&D program would ERDA undertake to establish whether such an energy future is achievable and how it might be obtained?

BACKGROUND

ERDA inherited most of its programs from the Atomic Energy Commission and from the Office of Coal Research in the Department of the Interior. These programs emphasized large-scale energy supply projects in the nuclear and coal technologies. ERDA has been mandated by the Congress to undertake energy conservation research, but as yet this program has not fully developed, and it is not yet possible to state with assurance what the payoff from this type of research will be.

Although preliminary analyses suggest that the payoff is potentially large, the situation is especially complex because of the degree of fragmentation in the end-use sectors as compared to energy supply sectors, Another complicating factor in estimating the payoff from conservation is the division of responsibilities between ERDA and other agencies within the Government having responsibilities for the use of energy, notably the Federal Energy Administration,

Historically, government involves itself in the expansion of production and exploitation of natural resources but avoids intruding into how its citizens consume them. For example, the Nat ion's water programs have almost exclusively been designed to augment the supply of water, not to husband water at the point of use. The Helium Conservation Program never sought to reduce the demand for helium by end-use conservation practices.

This involvement by the Government with supply rather than consumption exists in the area of regulations and subsidies as well as in energy research. For example, the Federal Government contemplates assuring the producer of synthetic fuels a guaranteed price for his product in case the price of alternative fuels should fall, but does not consider supporting the investment by a homeowner in upgrading the thermal performance of his home. There is a mandated plan for a national solar energy laboratory to assure that new technologies to harness solar energy are pursued vigorously across the board, but no comparable intensity of effort and imagination has been directed toward creating programs to develop new end-use technologies. Yet the two sets of research problems involve similar areas of engineering and physics (heat transfer, surface properties of materials, energy storage), as well as similar problems of information dissemination.

9. ERDA's Basic Research Program

ISSUE

The goals of ERDA's basic research program have not yet been established. Considerable effort is required to organize a pertinent program of basic research.

SUMMARY

ERDA's program for basic research has largely been inherited from the agencies that it incorporated. It is not surprising, because of the short life of ERDA, but nonetheless worrisome, that the basic research program in large measure does not reflect ERDA's R, D&D goals. In particular, a need exists to reexamine (a) the relationship between ongoing research and ERDA's program disciplines, (b) the integration of basic and supporting research, (c) the distribution of emphasis on in-house and contracted research and (d) the role of the national laboratories vis-a-vis universities and industry. In addition, the program indicates no basic research in the social sciences, which could have a significant impact on the institutional, legal, and social aspects of ERDA's program.

QUESTIONS

1. What are the pros and cons of a research policy that separates basic and supporting research?
2. Does ERDA intend to reorient its research program to reduce the emphasis on nuclear power and high-energy research relative to materials and molecular research?
3. How does ERDA intend to deal with "inherited" ongoing research that seems inappropriate or redundant in terms of ERDA's mission?
4. How does ERDA envision the research role of the national laboratories, the universities, and industries? How does ERDA plan to rationalize and balance these various research capabilities?
5. With particular regard to the university role in energy research, how does ERDA view the establishment of "Centers of Excellence" for energy-related research in the pure and applied sciences, engineering, and interdisciplinary programs dealing with environmental, health, and policy issues?
6. What is ERDA's view and intent with respect to social science research, which bears on the institutional, social, and legal aspects of its energy program?

BACKGROUND

With regard to the issue of research disciplines, ERDA's Plan (volume II, p. 125) identifies materials and molecular research as two of the four basic (physical) research areas, but practically all the budgetary emphasis in FY 76 is devoted to research associated with nuclear power and to high-energy physics. Despite the clear value of high-energy physics, there is some question as to whether it properly belongs to ERDA rather than, say, to the National Science Foundation, since it does take by far the lion's share of ERDA's basic research budget. On the

other hand, basic research efforts are weak or nonexistent in nonnuclear aspects of materials, combustion, thermodynamics, fuel chemistry, environmental processes, nonnuclear radiation, non fusion plasmadynamics, biomedicine, geology, cryogenics, and other disciplines pertinent to the nonnuclear ERDA programs. Assessment of the basic research program is therefore needed to align it more closely with the overall energy goals stated in ERDA-48.

With regard to integrating basic and supporting research, there appears to be some indication (ERDA-48, volume I, p. VIII-11) that the polarized research management policy characteristic of the Atomic Energy Commission may be carried over into ERDA. Although there are some benefits to this policy, such an approach can tend to isolate scientific and engineering research and, therefore, has not produced innovative advances in technology comparable to those, say, in the pace-setting electronics laboratories, where a centinuous spectrum of applied and fundamental research has been carried out under the cooperative leadership of scientists and engineers, Experience has shown that those charged with engineering responsibilities and constrained by timetables are not effective managers of basic research, whereas scientists do not generally apply their insights to the solution of practical problems when they are isolated from engineers and participating in mission-oriented problems. The optimum solut ion to innovation in advanced technology is, therefore, cooperative leadership between scientists and engineers, rather than separation of basic and supporting research. Such interdisciplinary teams, sharing a common sense of responsibility, are characterized by elements:

- A large mea sure of 1oca1 management autonomy.
- A definite, though broadly defined, mission.
- Full-time, interdisciplinary technical and nontechnical staff selected by management to implement an engineering objective having a multidisciplinary dimension,
- Adequate support that allows for program continuity by committing a full-time staff engaged in high-risk, high payoff technical development.
- Intelligence and strong personal motivation for performance at all levels of the organization.

Neither management practices nor funding decisions by ERDA have yet given adequate recognition to the advantages of interdisciplinary organizations.

Aside from programs inherited from the National Science Foundation, the bulk of ERDA's research is performed at the national laboratories, As a consequence, the extensive national research capability available at the universities and in industry has not yet been utilized effectively.

One mechanism for utilizing these capabilities is the establishment of university-based centers of excellence for energy-related research. Such centers should often assure continuity of funding for reasonably long periods of time *(5* to 1 0 years), thereby eliminating the costly and time-consuming necessity for annual proposal preparation and providing the necessary long-term support for both faculty and student research participation, An important benefit is thus the training of the students needed to tackle the Nation's energy problems. Precedents for such university centers of excellence for energy research are the successful Interdisciplinary Laboratories for Materials Science, which have been supported on a continuing basis by Atomic Energy Commission and Advanced Research Projects Agency at a number of major universities.

10. Commercialization

ISSUE

The development of effective commercialization policies and procedures is not adequately addressed in the ERDA Plan.

SUMMARY

ERDA-48 identified commercialization program and the plans for its implement at ion; however, ERDA has not considered the commercialization process in sufficient detail, For example, specific mechanisms for assuring ERDA/industry coordination are not clearly outlined, and the administration's relationships with international companies is not defined. Moreover, the Plan does not address a number of very important issues; e.g., long-term support of energy industries that can be undercut by reduction in foreign energy prices. Because of the complexity of ERDA program markets, an effective commercialization program is very difficult to formulate. The key questions are which commercialization processes could be suitable for implementation and how will implemental ion be achieved.

QUESTIONS

1. What formal procedures and agencies have been established by ERDA to facilitate coordination with private industry?
2. In specific terms, how does ERDA plan to encourage industry to participate in the development of new energy technologies?
3. How does ERDA plan to ensure that small energy companies and energy consumers are not excluded from its R, D&D program and their subsequent commercial implementat ion?
4. How does ERDA plan to address the problem Of long-term support of neocommercial energy industries; i.e., those which require large capital expenditures but which can be underbid by lowered imported energy costs?
5. Does ERDA plan to conduct or support any research in commercialization and incentivization policy and procedures?

BACKGROUND

ERDA's commercialization philosophy is outlined in chapter VII, volume I, of ERDA-48. The procedures for applying this philosophy to specific projects (volume II) are, for the most part, very general and, in some cases, inconsistent from one program area to another, Clearly, the Plan needs a more detailed explanation of commercialization plans, a more carefu1 definit ion of patent policies and procedures, and further discussion of the role of small industries and energy consumers in the ERDA program,

Several aspects of commercialization and the ERDA/industry relationship problems do not appear to have been adequately considered in ERDA-48 such as the relationship between ERDA and international companies, the possible need for long-term government support of commercial-sized energy programs, and the role

of ERDA in coordinating the commercialization process with other government agencies.

Although ERDA-48 indicates that the ultimate objective of each research program will be its introduction into the commercial market, the diverse nature of the ERDA programs presents a number of complicating factors.

First, the market for the ERDA R, D&D output is both diffuse and, in some cases, poorly defined. Whereas, the products of the Department of Defense- and the National Aeronautics and Space Administration-supervised research and development have been primarily used internally, and those of the Securities and Exchange Commission were intended for the power production industry, the market for the results of successful ERDA programs may range from the large energy companies to the local baker. To some extent, this problem can be ameliorated by including comprehensive industrial and consumer participation in the planning phase of new projects, These groups probably have the best perception of society's requirements, and their early involvement in program planning can help to prevent the development of products and processes that simply "won't sell." ERDA-48 does not recognize or recommend the utilization of this type of input.

Second, in those programs where the market is clearly defined, the ERDA Plan implies that commercialization will occur when the risks involved in introducing a new energy technology are reduced to the point where private industry will be willing to invest in it. However, corporate investment decisions are based not only on the risk of investment loss versus potential profit, but also on the size of the investment required, the compatibility of the technology with the overall company structure, the breadth and centinuity of the market, the long-term availability y of raw materials and other necessary resources, and many other factors.

The Federal Government may therefore seek to tilt corporate decisions in a desired direction by offering special incentives, such as tax credits, loan guarantees, and direct subsidies. However, the complexity of the energy milieu may require new incentive concepts. It will be increasingly important to plan incentives much earlier in the R, D&D process; the need for multiple incentives will probably increase; and active private participation may require continued Federal support, in one form or another, well into what is now thought of as the commercialization phase of project development. At present, the basic mechanism to create incentives in new energy technologies is not well understood, and there is little indication in ERDA-48 that research in understanding these mechanisms is contemplated,

A third major problem involved in bringing ERDA programs to the commercial stage is that of "blurred competitive horizon s." For example, although it may be possible to estimate fairly accurately the cost of producing gasoline from oil shale, the oil-exporting nations can always lower the prices of oil to undercut any potential market for such gasoline, Thus, the construction of shale-oil extract ion and refinement facilities may depend on subsidies in some form by the Federal Government. Projects of this type may, therefore, never reach a true commercialization stage. Consideration could be given to forming special public agencies (e.g., Amtrak) to manage enterprises of this type. However, formation of such enterprises could have significant impacts on the Nation's basic economic structure. The present ERDA plan does not appear to address these cons ideations.

The success of ERDA's commercialization program will depend in large measure on its patent and proprietary rights policies. Many companies, particularly small ones, will be very hesitant to become involved in ERDA programs unless they are confident that their rights in these areas will be adequately protected. Efforts to develop acceptable regulations should begin immediately.

The existence and growing importance of multinational companies further exacerbates ERDA's difficulties in program commercialization, The desirability of subsidizing such companies, the problems involved in protection of United States patent rights, the differences in regulatory philosophy among countries, the effect on international treaties and agreements, and numerous other issues have only been touched on in ERDA-48.

Although many aspects of commercialization lie outside ERDA's jurisdiction, the lead role of ERDA in energy R, D&D and its important role in commercialization as recognized in ERDA-48 requires ERDA to understand the overall commercialization process and to employ this understanding effectively.

11. Resource Constraints

ISSUE

Careful attention should be given to assessing energy resources, since they represent assumptions basic to the ERDA Plan.

SUMMARY

The direction and timing of the ERDA Plan is predicated, to a large extent, on the Nation's energy resource base, An incorrect assessment of the extent of all or part of the resource base could cause severe distortions in ERDA priorities and schedules. If the estimated recoverable reserves of a given resource are greatly overestimated, and several different technologies are developed and commercialized which would utilize that resource, the Nation could be in the position of developing a new energy infrastructure that would quickly find itself running out of fuel. On the other hand, underestimating these resources could cause a dependency on uneconomic energy systems,

To reduce the probability of such occurrences, accurate determinations of the upper and lower bounds of recoverable resource estimates are required, necessitating high priority efforts to improve the methods for making these estimates.

QUESTIONS

1. How reliable are energy resource estimates for petroleum, natural gas, coal, uranium ore, and thorium ore?
2. How are these uncertainties incorporated into the R, D&D strategies?

BACKGROUND

There have been several estimates of energy resources made over the last few years, for which extensive ranges of values exist. For example, undiscovered recoverable natural gas resources have been estimated to range from *322* to *5,572* trillion cubic feet. The most recent survey gives a range of 524 to 857 trillion feet. Similar wide variations are available for oil, coal, and uranium. A more complete analysis of energy resources is given in Energy Alternatives, A Comparative Analysis, U.S. Government Printing Office, Stock No. 041-011-00025-4, May 1975, Washington, D.C. These documents show that a great deal of uncertainty still exists regarding the nature of our energy resources and points out the need for developing better estimate methodologies,

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12. Physical and Societal Constraints

ISSUE

Numerous physical, institutional, and social constraints may limit the orderly development and implementation of the ERDA energy plan.

SUMMARY

Potential physical constraints to the implementation of the ERDA Plan include water requirements, materials limitations, air pollution, land use, and net energy considerations, Among the social and institutional constraints are manpower; capital; lags in technology transfer; information accession, retrieval, and dissemination; regional and community impacts of mining and plant construction; metropolitan dislocations caused by fuel shortages and price increases; and social acceptability of new technology.

QUESTIONS

1. What is ERDA's strategy for identifying and assessing the physical and societal constraints upon the implementation of the National energy plan?
2. What levels of effort are planned with respect to systems studies, cost-benefit analysis, technology assessment, and other energy policy planning research?

BACKGROUND

The identification and assessment of materials limitations which might arise in the construction and operation of large numbers of energy conversion facilities is a major task which ERDA must address, Examples include not only rare photovoltaic materials such as gallium, cadmium, and iridium for photocells, but also more common materials such as copper, aluminum, high temperature alloys, and conversion resist alloys. Extensive studies of near-term potential shortages in materials, components (e. g., valves and pumps) and major equipment (e.g., drill rigs) are described in the Project Independence Report.

Air pollution constitutes a major "expenditure" of natural resources, with oxygen depletion, carbon dioxide buildup, and thermal input representing possible long-term constraints. Land, too, is a natural resource of which certain types and locations are already in short supply.

Some of the nonphysical constraints may be more difficult to assess than the physical ones. For example: in principle, capital for economic ventures is always available at some interest rate, In fact, however, government intervention may be appropriate when an overriding social need, such as independence from imported oil, is identified. There are many forms which such intervention might take; careful study is needed in this area to ensure that a wise course of action is chosen.

Information handling—accession, retrieval, and dissemination—and technology transfer constitute a set of closely related institutional constraints. An objective methodology for assessing the impact of a new technology—let alone quantifiable measures of social acceptability—has yet to be developed,

Another set of social constraints, perhaps the

least understood and hardest to define, concerns the regional and community impacts, including the social acceptability, of the drastic shifts expected in energy supply and demand. Where and how people live affec t the amounts and kinds o f energy they consume; conversely, fuel availabi1ity and cost significantiy affect 1iving patterns and associated urban and suburban development. Furthermore, some of the remote, sparsely populated regions of the Nation in which most new coal mining and processing plants must be located are already beginning to experience severe social, political, and institutional stra ins from the large influx of new workers and their families. (For example, a 1,000 MW nuclear plant requires a peak construction site force of 2,000 to *3,000* workers; coal-fired powerplants, as well as gasification and liquefaction facilities, will require similarly large forces,) Furthermore, workers and their families may be stranded in remote locations when construction is completed, thereby contributing to as serious a set of community problems at the end of a program as at the beginning. These and other potential problem areas could benefit from further research.

Some of the constraints enumerated in the summary are addressed elsewhere in this report: See chapter II, issue 16 on Water Resources; chapter VI, issue 14 on Air Pollution; issue 16 of this chapter on Net Energy.

13. Overemphasis on Electrification

ISSUE

The ERDA Plan appears to lean toward an overemphasis on electrification. This lack of diversity especially in the long-term "inexhaustible" sources, may not be the most effective approach.

SUMMARY

All three major "inexhaustible" sources identified by the ERDA Plan are producers of electricity having high capital cost and low operating or fuel cost. Examination of the functional energy needs indicates, however, that other concepts, although having less ultimate potential, should be given equal priority, Intensive electrification itself will have a noticeable social impact and may present problems of vulnerability y and reliability. Alternatives include expanded direct use of solar, geothermal and other direct heat sources for industrial process, production of synthetic 1iquid or gas fuels b y solar or nuclear energy, and increased emphasis on hydrogen, biomass and conservation.

BACKGROUND

Breeder reactors, solar-electric systems, and f us ion reactors identified in the ERDA Plan as t he three "inexhaustible" energy sources have a certain degree of functional commonality, All are capital intensive, have a low fuel cost, and are primarily suited to the production of electricity, This commonality, particularly the intensive electrification these technologies will entail, may dangerously narrow future options. Thus this approach must be thoroughly analyzed to make sure that viable alternatives are not lost by default.

There is already considerable concern about the ability of the energy industry to raise needed capital, (see issue 12 of this chapter), If industry is forced by resource depletion and lack of alternatives to deploy the capital-intensive technologies, but is unable to raise the capital, massive Federal subsidies may be required.

Electricity has many advantages as an energy form, It can be generated from a variety of resources and mixed with impunity. At its point of use it is clean, efficient, and versatile. Increased use can reduce consumption of petroleum, particularly in electric cars and trains, heat pumps for space conditioning and medium- temperature process heat, etc. Nevertheless, intensive electrification involves many uncertainties. The environmental problem associated with heat rejection is a primary concern in the massive generation of electricity, The very complexity of the "inexhaustible" systems makes them more vulnerable to equipment malfunction or sabotage, The reliability of present day nuclear plants has been less than expected; breeders and fusion reactors can be expected to suffer from similar problems, Solar electric systems and transmission networks are especially vulnerable to sabotage. The disruptions caused by the 1965 northeast blackout were severe; a similar event in an economy much more heavily dependent on electricity could be devastating.

The potential alternatives to these electricity-intensive ERDA choices are more nearly aligned with current energy demand, over half of which is for thermal energy and half of the remainder for transportation. Synthetic fluid fuels can be emphasized; they are not mentioned in ERDA-48. Solar or nuclear energy could be used in the production process. The production of hydrogen from water directly by light (photolysis) or moderate temperature catalytic reactions show promise, but need a substantial research program. The direct use of solar and geothermal energy is feasible for many moderate temperature industrial processes. Biomass fuels from energy "plantations" or from wastes, mentioned in the Plan, could contribute to heating and transportation. The relative lack of emphasis on conservation is also rather surprising, in view of the great benefits it offers in reducing the demand for now costly energy,

14. Methodology and Assumptions Used in Developing the R, D&D Plan

ISSUE

The ERDA Plan relies on methodology and assumptions for developing R, D&D priorities that appear to bias the priorities toward high technology and capital intensive energy supply alternatives and away from end-use technologies.

SUMMARY

The ERDA R, D&D plan makes use of six energy scenarios as essential elements in arriving at R, D&D priorities. An analysis of this approach discloses a number questionable assumptions which tend to distort the value of various R, D&D options. Included among these assumptions are:

- the scenarios all assume the same set of final demands,
- calculated energy "system capital costs include only supply side costs and ignore consumer costs, and
- the scenario emphasizing improved efficiency in end-use assumes increased efficiency will have an effect only up to about 1985, after which exponential growth resumes.

These and other deficiencies tend to minimize the impact of end-use technology R, D&D and bias the choice of research priorities toward the supply sector. Although ERDA appears to recognize this problem, improvements in the application of the methodology are needed to develop the most effective set of energy R, D&D priorities.

QUESTIONS

1. How sensitive are the R, D&D priorities arrived at by ERDA to the methodology and assumptions used in the development of the six scenarios?
2. Does ERDA believe it can develop a "model" to generate R, D&D priorities? How important will "professional judgments" be in developing R, D&D priorities?
3. How are future projections of energy demands arrived at? How do they affect the R, D&D priorities? What types of social, economic or institutional changes will lead to greatly reduced demand projections or greatly increased demand projections?

BACKGROUND

The ERDA Plan for R, D&D makes use of six scenarios:

(1) No New Initiatives;
(2) Improved Efficiencies in End Use;
(3) Synthetics from Coal and Shale;
(4) Intensive Electrification;

(5) Limited Nuclear Power; and
(6) Combination of all Technologies,

ERDA uses these scenarios as an essential element in arriving at R, D&D priorities: "Based upon an analysis of scenarios, the status of the candidate technologies, and the extent of the resources they would use, a national ranking of R, D&D technologies have been developed to identify priorities for emphasis in the Plan" (ERDA-48, volume I, pp. 5 and 6).

The scenarios used were generated, according to appendix B, by using a "judgmental procedure." Analysis of the approach used discloses a number of problems, a partial list of which follows.

- The scenarios all assume the same set of final demands, The possible effect of price on demand does not appear to be included in the analyses in any way, For example, it is assumed that air passenger miles will increase by an average of 8.14 percent per year in the 1972-85 time period.
- Calculated energy system capital costs include only supply side costs. Consumer costs are not included in the optimization calculation, thereby biasing the ERDA analysis in the direction of R, D&D to decrease supply costs, which will minimize the potential impact of R, D&D on end-use capital costs (e. g., refrigerators, heat pumps, and solar home heating systems),
- In scenario 1, increases in energy utilization efficiency as a result of the rising cost of fuel are not considered. Since this is the reference scenario, the distortion caused by this omission is perpetuated in all the other scenarios that ERDA develops.
- The "no new initiatives scenario" assumes automobile efficiency will be 17.5 miles per gallon in 1985, and 20 miles per gallon in 2000. Many persons feel automobile efficiencies will be substantially better than this even without substantial government intervention,
- The scenarios developed did not take into account constraints due to capital availability, manpower restrictions, environmental control regulations, materials supply limitation, competition for water resources, or regional sensitivities.
- The scenario emphasizing improved efficiency in end-use (scenario 2) assumes increased efficiency will have an effect only up to about 1985. (see ERDA-48 volume I, fig, 5, p. V-5). Thereafter exponential growth resumes. Thus conservation R, D&D is assumed to have negligible long-term impact. As discussed in detail in chapter V of this report dealing with conservation, it is believed that there are many areas where conservation R, D&D might have a long-term and continuing impact.
- While solar electric power plays a role in some of the scenarios, solar heating of buildings does not. This technology, which is thought by many to offer significant potential by 1985 and major potential by 2000, receives only limited emphasis in any of the scenarios—a maximum of 3.5 Quads* in the year 2000.

* **A Quad is** defined as one quadrillion Btu's.

15. ERDA Management Policy

ISSUE

ERDA's present management policies could hinder achievement of its goals.

SUMMARY

Present ERDA management practices have three recognizable drawbacks:

- Internal project management tends to impose excessively detailed restrictions on R, D&D program.
- Project management delegated to outside agencies or firms has been awarded to organizations having excessively detailed management structures, with a corresponding loss of ERDA program control.
- Improper balance between systems analysis and proof-of-concept experiments.

QUESTIONS

1. Has ERDA undertaken any formal analyses of the management problems and successes of similar organizations? If so, what are the results?
2. Has ERDA formally considered the use of less centralized project management? If so, what conclusions have been reached?
3. Has ERDA adopted any management procedure which it considers undesirable to protect itself from public, executive, or legislative criticism?
4. How does ERDA envision its relationship with the Solar Energy Research Institute?
5. What does ERDA consider to be the appropriate roles for systems analysis, modeling, field experiments, and judgmental considerations in its decisionmaking procedures?

BACKGROUND

Establishment of ERDA as a new agency provides it with excellent opportunities to benefit from the experiences of older groups and to initiate imaginative management procedures and techniques. For example, at the Department of Defense and other agencies a growing tendency is to increase the extent and detail of control over research and development programs. Between 1947 and 1973 the Armed Services Procurement Regulation grew from approximately 125 pages to about 3,000. By 1971, there were almost 1,300 directives involved in the systems management process of major defense programs. This vast expansion of centralized program control inevitably caused large increases in the number of contractor and Federal personnel involved in systems management.

This increase in management effort might well be justified if comparable improvements in R, D&D results were noted. However, comparisons of the present R, D&D procedure with earlier, less centralized U.S. procedures and with foreign

procedures reveal few differences in technical, schedule, and cost performance.

A recent study of worldwide space and aviation research projects indicates that the most successful programs have been characterized by an individual identifiable as chief designer, the use of small design teams, internal project autonomy, small governmental project offices, austere budgets, and strict adherence to schedule. Although there are obvious differences in the R, D&D projects envisioned by ERDA and those undertaken by the aerospace community, ERDA should nevertheless give serious consideration to these factors in developing management procedures.

In analyzing its management procedures, ERDA should carefully consider the need for new agencies to support its research requirements. The Solar Energy Research Institute, mandated by the Congress in 1975, is an excellent example of the type of new agency that might be established to support ERDA's R, D&D goals. At present, ERDA is exploring the appropriate role and structure of such an institute through a National Academy of Science study, requests for comments from public groups, and internal analysis. Issues to be considered include the relative stress to be given fundamental and applied science versus demonstration projects, the inclusion of university and private research groups in the program, the overlap between solar and conservation research, and the nature and extent of institutional problems involved in widespread solar energy utilization,

Finally, ERDA should give careful consideration to the appropriate use of systems analyses in lieu of critical field experiments needed to test the viability of new energy technologies. The improper use of system analysis in such instances can constitute a serious obstacle to cost-effective, rapid and orderly assessment of new technologies which require primary experimental demonstration of feasibility, Although there is no quarrel with good systems analyses that help to generate an overview essential to the success or failure of a concept, the improper substitution of systems analyses for critical experimental tests is basically unsound.

16. Net Energy Analysis

ISSUE

Net energy analysis can aid in decisions as to which existing and developing technologies deserve emphasis, but this methodology must be employed with caution.

SUMMARY

Net energy measures energy output relative to energy input, thereby indicating which technologies are likely to be most useful. However, the concept has been very loosely interpreted; as a result, comparisons of numerical estimates can be misleading, due to the use of differing definitions of net energy. The terms and assumptions used in calculations of net energy ratios must, therefore, be carefully defined. In addition, the numerical values of net energy ratios have different implications for different energy technologies, and even for different plant locations. Moreover, net energy may not comprise the most significant criterion in setting energy policies and pursuing national objectives; for example, reduction of oil imports may be more important than the net energy ratio of a coal liquefaction facility. The ERDA Plan does not address any of these considerations, nor does it establish quantitative net energy criteria for the evaluation of energy technologies.

QUESTION

1. What are ERDA's intentions regarding the development and use of net energy analysis?

BACKGROUND

Energy analysis is a method used to determine the amount of energy required to provide a product or service. Net energy analysis is used to determine the energy required to produce energy. For instance, to provide shale oil, the shale must be mined, transported and heated in order to release the oil. The energy content of the resulting oil is compared to the energy required by the above processes. For most technologies, the ratio of energy output to energy input must generally be greater than six in order for the process to be attractive.

Energy analysis is a subset of economic analysis. While decisions tend to be made on the basis of optimizing economics rather than energy, energy analysis can be useful when costs are unknown or when nonmarket forces are involved or contemplated. There are three main uses for energy analysis: to determine the energy ratio of a process, as in the shale oil example; to determine the time required for a new facility to pay back the energy invested in plant construction; and/or to determine, from a thermodynamic standpoint, the minimum energy necessary for a given process.

Energy analysis has yet to advance beyond the stage of establishing a coherent framework of definitions and accounting procedures. The assumptions underlying energy analysis are still subject to widely varying interpretations,

thereby yielding widely varying results. The most important difficulty involves determining the boundaries of the analysis. For example, in calculating the energy used in equipment production, how far back should one extend the calculations of energy used to manufacture the equipment required by the above process? In addition, how important are the differences in powerplant efficiencies or fuel sources which generate the electricity used in the process? Clearly, a great deal of research must be performed before net energy analysis can be a consistent and widely accepted methodology. The ERDA Plan and Program virtually ignores the subject, despite the consideration of net energy as one of the five basic principles in the law establishing the agency.