An Analysis of the ERDA Plan and Program

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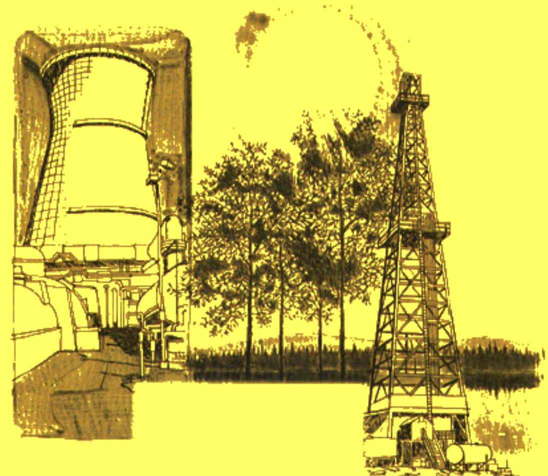

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Congress of the United States
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510

EMILIO Q. DADDARIO
DIRECTOR
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October 21, 1975

The Honorable Henry M. Jackson
Chairman, Committee on Interior
and Insular Affairs
United States Senate
Washington, D.C. 20510

The Honorable Olin E. Teague
Chairman, Committee on
Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Gentlemen:

On behalf of the Office of Technology Assessment, we are pleased to forward a report: An Analysis of the ERDA Plan and Program.

The report was prepared by the Office of Technology Assessment with the assistance of six panels of experts conversant with the major program areas of the Energy Research and Development Administration (ERDA). It is an analysis of the program plan submitted by ERDA to the Congress on June 30, 1975, entitled: A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future.

This report is being made available to your Committees in accordance with Public Law 92-484.

Sincerely,

OLIN E. TEAGUE
Chairman
of the Board

Sincerely,

CLIFFORD P. CASE
Vice Chairman
of the Board

Congress of the United States
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510

October 21, 1975

The Honorable Olin E. Teague
Chairman of the Board
Off ice of Technology Assessment
Congress of the United States
Washington, D. C. 20515

Dear Mr. Chairman:

In response to the requests *to* OTA from the Chairman of the House Committee on Science and Technology and the Chairman of the Senate Committee on Interior and Insular Affairs, I am pleased to submit a report entitled: An Analysis of the ERDA Plan and Program.

This report was prepared by the staff of the Office of Technology Assessment with the assistance of six panels of experts conversant with the major program areas of the Energy Research and Development Administration (ERDA) and personnel from three universities with centers for energy policy analysis.

It is anticipated that this analysis, which identifies major issues, summarizes their import, raises key questions, and provides background data, will be of use to Congressional committees reviewing the comprehensive energy research plan and program submitted by ERDA to Congress on June 30, 1975, in accordance with Public Law 93-577.

Sincerely,

EMILIO Q . DADDARIO
Director

INTRODUCTION

The Office of Technology Assessment is pleased to present this report on its analysis of the Energy Research and Development Administration (ERDA) Plan and Program "Creating Energy Choices for the Future. " The Plan, was presented to Congress on June 30, 1975 in accordance with Public Law 93-577.

The Office of Technology Assessment (OTA) was asked by Chairman Teague and Congressman Mosher of the House Committee on Science and Technology to analyze the Energy Research and Development Administration Plan and Program. This request was joined by Senator Jackson, Chairman of the Senate Interior and Insular Affairs Committee and by the Joint Committee on Atomic Energy.

ERDA became operational on January 19, 1975. It was created by combining elements from several agencies, notably the Atomic Energy Commission, Department of Interior, National Science Foundation, and Environmental Protection Agency. During the initial months of its existence, ERDA's task was to develop and staff an organization which would concern itself with all forms of energy supply and use, not exclusively with one form of energy (e.g. as in the case of the AEC).

The Non-Nuclear Energy Research and Development Act (Public Law 93-577) which established ERDA, also required the agency to submit to the Congress a national plan for energy research, development, and demonstration, hereafter referred to as the Plan. This document was issued as ERDA-48, volumes I and II.* Volume I articulates a set of goals for national energy R&D policy, discusses these goals in light of a set of energy scenarios, and identifies R&D priorities for three time scales: near-term (to 1985); mid-term (to 2000); and long-term (past 2000), Volume II of the Plan sets forth a set of specific programmatic elements intended to achieve the Plan objectives.

In the letter from Chairman Teague and Congressman Mosher to OTA, dated December 17, 1974, they foresaw that before the Congress could satisfactorily judge the Plan and Program that would be submitted to it by ERDA, analysis, interpretation, and evaluation would be required. Since the ERDA plans reflect the President's view of national energy R&D policy, they will in large measure determine the broader options for our future national energy policy. The OTA assessment of the ERDA Plan and Program is intended to provide the Congress with much of the background information necessary for an effective analysis of ERDA's energy R&D programs.

The analysis was performed largely by task groups assembled in each of the ERDA major programmatic areas:

1. Fossil Energy;
2. Nuclear Energy;
3. Solar, Geothermal, and Advanced Technologies;
4. Conservation; and
5. Environment and Health.

* The ERDA Plan is supplemented by certain additional materials in the area of solar energy. These are ERDA-49, National Solar Energy Research, Development Demonstration Program (June 1975), and ERDA-23, National Plan for Solar Heating and Cooling [March 1975).

These panels, whose members are identified at the beginning of each chapter, were structured to contain a balance of viewpoints; participating authorities were drawn from major manufacturing industries, energy utilities, academic research centers, public health disciplines, environmental protection groups and professional engineering, architectural, and legal societies. The five panels addressed specific aspects of energy, development, and demonstration in week-long sessions starting in early July, A sixth panel, which included the chairmen of the first five groups, was assigned the task of providing a coordinated overview. Each task group prepared written material on the important issues it had identified.

Three universities which have developed active centers for energy policy analysis provided personnel to support the task groups and to assist the OTA staff in conducting this project. Staff members from the Massachusetts Institute of Technology, the University of Oklahoma, and the University of Texas at Austin worked with each of the six review panels, aided in the preparation of this report, and prepared background papers on a variety of topics not easily covered by a task group. Independent papers on other subjects were also prepared by a number of diverse outside groups and individuals. Critiques of the ERDA Plan were solicited from a wide range of organizations.

In undertaking this analysis, the OTA task groups relied not only on the ERDA Plan and Program, but also on the President's amended budget; interviews with key energy staff members from the Environmental Protection Agency, Federal Energy Administration, and Office of Management and Budget; and interviews with a large number of senior ERDA management personnel. Special thanks are due to ERDA Administrator Robert Seamans, Deputy Administrator Robert Fri, Assistant Administrators Roger LeGassie (Planning and Analysis), Philip White [Fossil), Richard Roberts (Nuclear), John Teem (Advanced Systems), James Kane (Acting–Conservation), and James Liverman (Environment).

This report contains an executive summary with the major conclusions of each task group and a chapter for each of the six task groups, includes a summary, and set of related issue papers representing the diverse viewpoints of the task group members. Each issue paper provides a list of specific questions relating to the ERDA Plan.

Attachment I contains critiques of the ERDA Plan received from diverse interest groups listed in the attachment.

The OTA staff effort was directed by Dr. Jon M. Veigel. The regular OTA energy staff of Mr. Alan T. Crane, Mr. T. Patrick Gaganidze, Mr. Lionel S. Johns, Ms. Linda M. Parker, and Ms. Joanne M. Seder. The staff was supplemented by Ms. Pamela Bloomfield, Dr. George Leppert, Dr. Richard E. Rowberg, Dr. George M. Seidel, and Dr. N. Richard Werthamer. Dr. Rowberg was on loan from the Federal Power Commission. The others came from universities or private industry.

CONTENTS

EXECUTIVE SUMMARY

The ERDA Plan (volume I) is a significant milestone in the evolution of a long-term national energy policy, However, the ERDA Program (volume II), to implement this plan does not appear adequate to achieve the stated goals,

In particular, there are two broad areas in which the differences between the policy goals mandated by Congress and the programs proposed by ERDA to meet those goals are especially significant. These deficiencies, unless remedied, could impede the solution of short-term and mid-term energy problems by the United States, which could lead to an increased dependence on foreign energy sources.

The first deficiency occurs because of ERDA's pursuit of technological options at the expense of a focus on a broader approach toward the solution of energy problems. Simply establishing technical feasibility is insufficient as non-technical constraints may prohibit implementation. Such constraints could include any or all of: transportation, resource, manpower, and capital availability y; public acceptability; or institutional, jurisdictional, economic, and environmental compatibility. If ERDA is to supply solutions to energy problems as mandated by Public Law 93-577, none of these can be neglected. If ERDA confines its activities predominantly to the proving of the feasibility of technological options, some other entity should address the more complex issues underlying energy solutions. In such a case clear coordination with ERDA would be essential.

The second departure from congressional mandate is to be found in the emphasis of both the ERDA Plan and Program on options directed toward increased energy supply, relative to the programs in end use demand reduction, In Public Law 93-577 (Sec. 5(a)(l)), the Congress defined energy conservation as meaning "both improvement in efficiency of energy production and use and reduction in energy waste. " The law requires energy conservation be "a primary consideration in the design and implementation" of the ERDA program, Yet only 2 percent of ERDA's budget appears to be allocated to conservation programs.

It is well recognized that expansion and conversion of our large energy supply systems will be very costly and cumbersome, but that our dwindling oil and gas reserves dictate such modification. By contrast, successful widespread implementation of conservation programs with increased efficiency or waste reduction objectives can have both a rapid and a continuing effect. Such improvements need not be technologically complex; they may include merely removing jurisdictional or institutional constraints, such as building codes which require energy-inefficient designs.

If ERDA is to provide near-term and mid-term energy problem solutions, conservation through efficiency and waste-reduction programs should be an essential ingredient. The present ERDA program orientation toward developing complex technological supply options for the long-term overshadows the importance of less-complex *so* lutions with near-term potential,

OVERVIEW ISSUES*

I. The Nature of the Energy Goals

In preparing its Plan, ERDA proposes five goals which, taken together, may constitute the energy policy for the Nation.

The five energy goals are stated as follows:

1, To maintain the security and independence of the Nation;

2. 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);

3. To provide for future needs so that life styles remain a matter of choice and are not limited by the unavailability of energy;

* Attachment II, page 311, compares overview issues to Public Law 93-577 and Public Law 93-438.

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

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

These goals and the emphasis among them warrant careful congressional review. Without agreement between the Administration and Congress on these overall objectives and priorities, ERDA's development of an R, D&D program is more difficult.

Review and consensus become all the more appropriate in view of the major influence these goals and their priorities will have on the Nation's economy, quality of life, environment, foreign affairs, and many other sectors.

2. The ERDA Response

ERDA acted ambitiously in proposing the set of national energy policy goals, Its interpretations of them are much too modest, however,

Basically in addressing the energy goals ERDA adopted a narrow, hardware-oriented approach. Its R, D&D effort is designed primarily to develop technologies . . . rather than to explore solutions to energy problems.

An almost exclusive emphasis on technology has gotten results in some other national research effort s—not ably, in the space program and military weaponry,

In these cases however, the "missions" have been very sharply defined, decisionmaking has been centralized, and ample resources have been available. The relative narrowness of these miss ions allowed a heavy application of hardware, and success has been achieved,

The energy crisis is a far more complex and wide-ranging challenge. It is a problem spanning the whole of man's activity. It involves decisions from individual householders to entire blocs of nations. Its "solution" depends on natural resources and human values, new sources of fuel, public perceptions, and government and industry responses,

As a consequence, ERDA's narrow approach to the national energy policy goals might well fulfill a mission—developing new technology—without providing an answer—a secure energy future, Unresolved "nontechnological" issues—from inadquate incentives for commercialization, through environmental demands, competitive use of resources, to community resistance—could block the most sophisticated engineering achievement,

The OTA Overview Task Group identified a number of very specific issues with respect to the approach of the ERDA Plan and Program to the national energy goals. These issues have an important common denominator— they arise from, and reflect, the narrow, hardware-oriented approach reflected in ERDA's Plan and Program.

3. The Issues

The issues with respect to the ERDA approach are summarized as follows. Each of the following is treated in more detail in chapter 1.

(a) Insufficient emphasis is placed on international *considerations:* International cooperation is essential to cope with the environmental effects of energy-generating technologies; to address security issues such as, specifically, the management of nuclear materials and wastes, and to manage resources, like the oceans, that are a common world heritage. ERDA identifies such considerations in its Plan but barely recognizes them in its Programs.

(b) Incomplete plans are provided for coordination with other Federal agencies: Split responsibilities among Federal agencies are a major potential obstacle to a comprehensive and balanced energy R, D&D program. ERDA has been mandated by Congress as the leading energy R, D&D agency and has been given responsibility to integrate and coordinate national efforts, But it is not evident in ERDA's plans whether a framework is being established to permit adequate performance of this role,

(c) Inadequate provision is made for cooperation between ERDA and State and local governments. The involvement and support of State and local governments is crucial to the success of ERDA's projects. These levels offer strong experience and capabilities in important "nonhardware" areas such as water allocation, land use, taxing policies, manpower training, environmental controls, and public education. While the ERDA plan recognized the importance of close and continuous coordination, it does not include procedures or mechanisms for accomplishing it.

[d) Little attention is devoted to near-term (next ten years) energy problems: 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 nuclear reactors, shifting demand away from petroleum, and increased conservation practices. However, a review of ERDA's FY 76 budget indicates that only about 5 percent is devoted to solving near-term problems.

(e) Only limited attention is given to socioeconomic research and analysis in addressing the Nation's energy problems: Broad-ranging research is needed to identify non-technological obstacles to energy solutions and to better understand the relationships of energy and the quality of life. ERDA's program and budget 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 technical R&D.

(f) ERDA's program overemphasizes energy supply technology relative to consumption: In the past era of constantly decreasing real energy prices, little emphasis was placed on efficiency in "end-use"-energy consumption in the business or home. This, however, is now an area in which significant and cumulative gains could be accomplished.

ERDA's plan makes provision for energy conservation. But the focus is primarily on the near-term, estimates of long-term importance of improved efficiency in energy end-use are undefined.

(g) The development of effective commercialization policies is not adequately addressed in the ERDA Plan: Bringing a new energy technology to the point of commercial feasibility is a risky process, especially when it involves diffuse markets, the uncertainty of global energy and economic circumstances, the competition for capital. ERDA's Plan outlines a philosophy for commercialization, but clearly needs a more detailed explanation and careful definition of plans for developing a mechanism for coordination with industry.

(h) Careful attention should be given to assessing energy resources: An incorrect assessment of the Nation's energy resource base could cause severe distortions in ERDA priorities and schedules.

Recent analyses clearly show there is still major uncertainty regarding the nature of our energy resources and point out the critical need for developing better estimation methodologies,

(i) Physical, institutional, and social constraints may limit the progress of the ERDA Energy Plan: As indicated earlier, there are many potential physical and social constraints to the introduction of new energy technologies. The potential for program disruption by possible obstacles demands careful study by ERDA.

(j) The ERDA Plan appears to overemphasize electrification: All three major "inexhaustible" sources (solar, breeder, and fusion) identified by the ERDA Plan are producers of electricity, Yet intensive electrification will have a noticeable social impact and may present problems of vulnerability and reliability.

In order to avoid dangerously narrow future options, the long-term electrification approach should be more thoroughly analyzed than presently proposed to make sure that viable alternatives are not lost by default.

(k) The ERDA Plan relies on assumptions which appear to bias its priorities toward high technology, capital intensive energy supply alternatives: Many of these not only are questionable, but, further, tend to distort the value of various R, D&D options, ERDA plans do not take into account the effect of higher prices on energy demand; they do not include consumer costs in calculating the costs of new energy systems, and they assume exponential energy growth will resume after 1985.

This concentration of focus tends to minimize the potential impact of R, D&D to improve end-use energy efficiency and bias the choice of research priorities toward the supply sector.

(1) Application and questions with respect to net energy analysis receive little attention: "Net energy" measures total energy output relative to total energy input, thereby indicating which technologies are likely to be most useful,

This technique can aid in the establishment of priorities for existing and developing technologies, but research is needed before it can be a consistent and widely accepted tool. The ERDA Plan and Program is not responsive to the Act in this area.

4. Other ERDA Issues

In addition to the above issues related to ERDA's narrow approach vis-a-vis energy policy goals, the OTA overview analysis identified the following three concerns:

(a) There is a need for a reexamination of the overall energy R, D&D budget: The Federal energy R, D&D budget (about $2.3 billion for FY 1976) was largely an outgrowth of decisions made prior to the Arab oil embargo, and should be reexamined.

(b) ERDA's present management policies could hinder achievement of its goals: present ERDA management practices have three recognizable drawbacks: (1) Internal project management tends to impose inhibitingly detailed restrictions on the R, D&D program; (2) project management delegated to external organizations has been awarded to organizations having excessively detailed management structures, resulting in a corresponding loss of program control by ERDA; (3) there is too little emphasis on systems analysis and too much on proof-of-concept experiments,

(c) The goals of ERDA's basic research program have not yet been established: ERDA's program for basic research has largely been inherited from the agencies which it incorporated, It is not surprising because of the short life of ERDA, but nonetheless a concern that the basic research program does not yet reflect ERDA's basic R, D&D goals.

5. Possible Remedies

Whether or not ERDA assumes responsibility for the broader, "nonhardware" R, D&D issues described above, there can be no question of their importance. As emphasized earlier, technology alone will not solve the Nation's energy problems.

Thus, answers to the Nation's energy problems require that the programs deemphasized by ERDA in its narrow interpretation of its role be vigorously pursued somewhere in the Government. Most are not, at present, receiving priority attention anywhere.

One possible answer lies close at hand—in the Acts of Congress. The Energy Reorganization Act establishing ERDA and the Energy Research and Development Act authorizing its programs provide ample latitude for a broad-gaged, well-coordinated R, D&D effort led by ERDA.

ERDA's Plan in many instances acknowledges the need for such a broad perspective and program, In fact, the problems are not so much within the Plan itself—which is a serious and praiseworthy initial effort—but in the lack of broad commitment and coordination when the Plan, Program and Budget are considered together.

Within the mandates of the Congressional Acts, a variety of actions could be considered. They are summarized as follows:

(a) The scope of ERDA's mission could be expanded and clarified, particularly in the areas of demonstration and commercialization. A major requirement is to clarify ERDA's jurisdiction and responsibilities with respect to those of the Federal Energy Administration, the Environmental Protection Agency, the Nuclear Regulatory Commission, and the Department of the Interior, in order to remove overlap, and ambiguity and to provide the grounds for efficient and effective mission management.

(b) As noted, widespread utilization of newly developed technologies depends on a complex process involving the removal of nontechnological constraints on commercialization, industrial incentives, and technology transfer. This process requires further delineation than exists in the present ERDA Plan,

(c) Programs associated with the identification and evaluation of environmental, institutional, and societal constraints associated with alternative energy technologies should receive immediate and substantial attention,

(d) Programs directed toward increasing the efficiency of energy use should be accorded the highest priority,

[e) New efforts to assess global issues associated with energy, such as climate modification, international energy supply and demand estimates, the role of multinational energy corporations, and the link with ocean resources, should be instituted,

(f) The ERDA management approach, including the management of national and Federal laboratories and the role of contract R, D&D should be reevaluated.

(g) Closer working relationships with State and local governments, including their participation in ERDA program planning, should be established.

(h) The potential national benefit which would result from higher ERDA budget levels should be examined.

Fossil Energy

- There is an urgent need to develop increased supplies of oil and natural gas.
- Programs to develop synthetic fuels from coa1 and shale should continue to be given very high priority.
- The ERDA fossil energy program should emphasize the demonstration of technologies on a scale sufficient to provide reliable information for evaluating their technical, economic, and environmental feasibility.
- Attention should be directed toward the broad range of non-technological impediments that can seriously delay, if not altoget her block, the introduction of otherwise economically viable technologies.

By focusing on new technologies, the fossil fuel program (contrary to the supply projections contained in it) limits itself to an insignificant impact on energy supplies in the short-term—before 1985, The first priority should be to get better information about presently available technologies and to facilitate their use when feasible: primary oil and gas extraction from new sources (especially the Outer Continental Shelf) and enhanced recovery of oil. Many of the problems impeding the increase in production of liquid hydrocarbons are nontechnical in nature.

Techniques for the production of synthetic oil and gas from coal and oil shale are available now and should be vigorously pursued, Although the economic feasibility of many of these technologies is highly uncertain at present, the promise of second generation technologies may not be much brighter. In the meantime there is a need for better information about the impacts, economics, and operating experience of commercial-scale operations. It must be recognized that the era of abundant cheap energy is over—especially in the cases of liquid and gas fuels.

Because of the urgency of the national energy situation, the ERDA fossil-fuel program should emphasize the demonstration of available technologies at a scale appropriate to their stage of development: near-commercial scale for cases where no serious technical obstacles exist (such as high-Btu gas and possible oil shale with surface retorting), and pilot scale for cases where technical problems still need to be solved (such as tertiary recovery of oil, stimulation of tight gas formations, coal liquefaction, and low-Btu gas, combined cycle power plants). Better and more universally credible information can only be obtained through demonstration,

While fuel technologies are discussed in some detail by ERDA, too little attention may have been directed towards the broad range of impediments that can seriously delay, if not block altogether, the introduction of otherwise economically viable technologies, Institutional constraints must be addressed early if the technologies upon which ERDA is concentrating its efforts are to be brought to commercialization. It is questionable planning, for example, for ERDA to pour large amounts of funds into the development of a commercially feasible technology for coal liquefaction if the technology cannot then be used—because coal mines cannot supply the coal, transportation facilities are inadequate, capital is unavailable, or water is insufficient. The efficient use of ERDA R, D&D funds requires a systematic look at entire energy development systems. The fact that ERDA does not have the primary responsibility within the Federal Government for dealing with some of these constraints is not a sufficient response; all the more reason exists in such cases for concern that the Government may not adequately consider some components vital for the successful introduction of new technologies.

Nuclear Energy Program

- Improvement in the light water reactor design and operational reliability is required to assure the near- and mid-term potential for nuclear energy,
- Uranium resources should be more precisely defined.
- A final decision on disposal of nuclear wastes should be made and implemented.
- The breeder reactor program continues to require analysis, especially as regards timing of need for the LMFBR cost and management,
- Alternative reactor systems need to be re-examined, and consideration given to ex-

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ploratory program plans to develop such systems,

- Reexamination, should be considered of the balance and rate of expansion of the fusion program.

The present generation of light water reactors is well developed, but problems still exist, as evidenced by rapidly increasing construction costs and disappointing reliability. In a major shift from AEC policy, ERDA recognized a responsibility to support light water reactor technology, but the program is not clearly spelled out; how does ERDA intend to encourage the standardization of power plants, improve their reliability, and build LWR's on floating platforms? Continuation of ERDA's LWR safety research is a part of this support, and should be encouraged,

The future of nuclear fission power is dependent on an adequate fuel supply. The present, highly speculative estimates indicate a uranium shortage early next century. More precise estimates are needed for better planning of LWR growth and scheduling of the breeder development program. The National Uranium Resource Evaluation (NURE) is now underway; when completed in 1980 it should tell us whether we have enough uranium to fuel the LWR's until the breeder can be deployed, It seems, therefore, that NURE ought to be pressed with more vigor than is evident in the ERDA program.

The rest of the fuel cycle—reprocessing, enrichment, and waste disposal—is probably not in as critical a state as is the supply of uranium, at least if the nuclear industry expands no faster than at the moderate rate now projected. Of the remaining components of the fuel cycle, waste disposal should be regarded as the one which needs most attention. In principle, safe disposal of reprocessed radioactive waste in salt appears to be technically feasible. Prompt resolutions of remaining questions and a firm decision by ERDA to proceed with a demonstration are urgently needed.

By far the largest component of the ERDA nuclear program is the development of an "inexhaustible" energy source based on fission breeders, in particular the liquid metal fast breeder. The high cost of the program, especially when compared to its French equivalent, has led to extensive criticism. In retrospect, it may be that the early emphasis on commercialization was premature and expensive. Recent management changes should streamline the project and help prevent further cost escalation, but their effectiveness remains unproven. Although the schedule for demonstration has slipped recently, delayed commercialization of the LMFBR is consistent with lower projections now being made for nuclear power growth. Safeguards against plutonium diversion is a problem intimately involved with the LMFBR, but adequate solutions appear to be possible.

With the creation of ERDA, AEC policies should be reexamined, Perhaps most importantly, it is now possible to reopen the issue of alternative breeder systems, Three such systems are being worked on: the light water breeder (LWBR), the gas cooled fast breeder, (GCFBR), and the molten salt breeder (MSBR), Of these only the LWBR is being pursued vigorously, It is appropriate to ask why the MSBR and the GCFBR should not receive emphasis at least comparable to the LWBR.

The plutonium-based economy entailed by LWR's and LMFBR's increases concern over plutonium toxicity safeguards against diversion and possible problems with long-term waste management. A nuclear system based on thorium (LWBR, MSBR, high-temperature gas-cooled reactor, HTGR, or thorium version of LMFBR), may be less vulnerable to some of these difficulties, Yet a fuel analysis has never been made of thorium-based systems as an alternative to the plutonium-based system; such an analysis is badly needed as a guide to comprehensive nuclear system development. Additionally, the role of high temperature process heat from nuclear reactors, most importantly the HTGR, should be examined. The use of nuclear energy for this purpose could save large amounts of fossil fuel.

Fusion is the other potential "inexhaustible" nuclear energy source, The prevailing opinion is that fusion will probably be successfully harnessed, and that it could be an attractive means of supplying much of the Nation's electrical energy next century. Thus fusion appropriately occupies a prominent position in the ERDA plan, yet there are reasons to remain cautious about the development of the program, Scientific demonstration of controlled fusion, i.e., achieving energy "breakeven" conditions, is still to be reached, This is the goal of the next generation of fusion devices, called "fusion test reactors", which in fact are large experimental devices to test the concept not generate power, They will operate in new regimes of physics and technology. Because these machines are so costly, a central issue is whether ERDA can meet its very heavy commitment to the tokamak fusion concept while, at the same time, preserving its options on other promising fusion concepts in case the tokamak is not successful,

Solar, Geothermal, and Advanced Technology Programs

- The ERDA solar-energy program underemphasizes the potential of solar heating and cooling relative to solar electric technologies.
- In its solar heating and cooling program, ERDA should consider giving increased emphasis to: user incentives, standards for measurements of equipment performance, and impact on utility peak demand of solar systems,
- Improved decision criteria in the solar electric program are needed to avoid premature exclusion of promising concepts. All the technologies proposed for solar electric generation presently have large cost uncertain ties.
- The legal and institutional problems associated with geothermal resources should receive greater emphasis in ERDA planning.

The principal issue raised with respect to the ERDA Plan concerns the relative emphasis accorded solar-electric and solar heating and cooling technologies, Solar-electric technology is identified by ERDA as one of the three long-term inexhaustible sources; solar heating and cooling is listed merely as an underexploited technology appropriate for mid-term utilization. The relative importance of these two technologies thereby implied by the Plan is judged to be out of balance. The technology and economics for solar water and space heating are available now, A greater near-term emphasis placed in this area relative to solar electric along with acceleration of the solar heating and cooling demonstration program, may be the most effective way to develop solar energy.

Solar energy is suited to many direct thermal applications, and it is in these areas that solar energy can have its most immediate impact on our energy economy and can contribute substantially as a long-term inexhaustible energy source, It is, however, extremely important that necessary attention be given to user incentives, standards for measurement of equipment performance, and the impact on utility peak demand of solar power systems, including wind-energy users.

Although no technical barriers exist to solar generation of electric energy, the high costs estimated for these technologies necessitate a long-term research program if they are to be economically competitive. The large cost uncertainties of different solar electric concepts (ocean thermal energy conversion, wind energy, solar satellite, solar thermal) necessitates development of precise decision criteria for alternative energy technologies. Consideration of resource availabilities is critical due to the extensive use of land and, in some cases, water, by solar electric systems. One specific concern with the ERDA Plan involves the apparent lack of consideration of a number of promising candidates for photovoltaic cell materials.

Legal and institutional constraints are more severe impediments to the rapid utilization of geothermal resources than are technical problems. The ERDA near-term projections for geothermal energy development appear to be optimistic, although geothermal resources do have the potential to meet ERDA goals, if not limited solely to electricity product ion. The most important role for geothermal energy in the United States may be in nonelectric uses, a role which is given inadequate significance in the ERDA Plan. Because each geothermal reservoir has unique characteristics, research strategy on power conversion will have to consider a wide variety of possible utilization systems in order to minimize resource waste.

Conservation Program

- The ERDA Plan for conservation is timid and underfunded, despite strong congressional encouragement,
- The conservation program contains elements largely unrelated to end-use conservation, a situation which threatens to keep the program unfocused and further exacerbate the problems of funding and staffing for end use conservation R, D&D.
- ERDA has not adequately established priorities within its conservation program.

- The success of ERDA's conservation efforts will depend on close cooperation with Federal, State and local agencies, industry, and private citizens.
- Nontechnological constraints could impede the implementation of energy conservation technologies unless addressed and removed,
- ERDA's program does not sufficiently address nontechnological aspects of energy conservation. Social science research is needed to:

  1. Identify and overcome institutional obstacles to implementation.
  2. Evaluate the economic (e.g., labor, capital, growth) implications of alternative conservation programs,
  3, Analyze the appropriate roles of Federal and State regulatory agencies with respect to energy use,
  4. Assist in continuing cost/benefit analyses of conservation options and research programs.

The new high price of energy has made our present use of energy wasteful and uneconomic. There are wide variations in the possible savings among energy use sectors but a major efficiency of energy use over pre-1973 practices will be cost-effective. The optimum rate at which the transition to higher efficiency should be made depends upon market factors, such as the inventory of existing stock, and upon nonmarket factors, such as the national policy decision to cut oil imports. There are, therefore, two reasons for active Federal energy conservation efforts: 1) to assist governmental, corporate, and individual energy consumers to become more energy-efficient in order to ease the economic hardship caused by higher prices; and 2) to accelerate this transition in accordance with the national policy of reduced dependence on imported oil. Although ERDA was assigned broad responsibilities for energy conservation R, D&D, and has been given strong congressional encouragement, the program as presently conceived is very limited compared to the productive opportunities in the near-term and major savings in the mid- and long-term. Only about two percent of the revised fiscal year 1976 budget sent to the Congress can properly be termed applicable to "conservation" activity; moreover, only about one percent is actually designated for end-use conservation programs.

ERDA's Plan contains a very broad interpretation of conservation, It includes increased end-use efficiency through use of technology and elimination of waste; fuel shifts away from petroleum; energy storage; and even capital savings in various parts of the supply/demand system, However important all these actions may be, there is danger that such a broad operational definition can shift the emphasis on conservation from the consumer to the suppliers and distributors of energy. For example, inclusion of electric power transmission and distribution and energy storage as conservation programs could mask a low level of commitment to important programs directed at increasing efficiency of energy utilization.

Federal investments in various supply and conservation efforts should be weighted in terms of their cost-effectiveness, taking environmental consequences as well as other nonmarket considerations into account. The amount spent to save a barrel of oil, or its energy equivalent, is directly comparable to the money spent on new domestic supplies to produce an additional barrel of oil or its energy equivalent. The ERDA Plan does not appear to employ this type of assessment in determining priorities, although there are many conservation opportunities that appear more attractive than many new supply options on this cost basis, When environmental costs are included, the advantage to conservation efforts usually becomes even more impressive. ERDA should incorporate this kind of trade-off analysis into its program decision structure more explicitly.

The implementation of energy conservation measures can be significantly influenced, not only by technical problems but by nontechnical difficulties as well. Impediments to the adoption of sound energy conservation practices include government regulations, building codes, lack of consumer understanding of life cycle costs, industry and consumer resistance to change, and capital availability, Development of technologies without regard for the institutional constraints, social impacts, and the imperfect workings of the market is unlikely to achieve optimal energy conservation results,

ERDA's separation of programs by end-use sector appropriately mingles research, development, and implementation. This problem-solving approach to conservation should prove very productive in coordinating the Federal program, assuring comprehensiveness and relevancy in research, promoting rapid information transfer, and facilitating effective implementation.

Environment and Health Programs

- Better integration of means to minimize environmental and health impacts should be integrated into the ERDA development programs.
- ERDA should analyze the environmental impact of the vastly enlarged use of fossil fuels in conventional technology envisioned in the Plan.
- ERDA should address the environmental and health problems that may be created by the emerging synthetic fuels technologies.
- Regulations concerning environmental quality should be analyzed as they often impose energy penalties.
- ERDA should examine the global environmental consequences of new energy technologies.
- ERDA should take a more active role in assessing its programs in the context of energy and non-energy demands for water.

The ERDA Program document contains an extensive description of proposed activity in environmental, health, social, and institutional topics. Almost all of this description occurs in the sections of the report devoted to Environment and Safety and Systems Analysis. Discussion of these topics in the sections of the report devoted to technology development generally consisted of one-line statements recognizing the existence of a potential constraint. There was no reference in the schedules appended to technology oriented sections to the environmental or health research programs. Interviews with ERDA personnel yield the strong impression that the stated objective of integrating the environmental control research into the technology development was at present illusory. Given that environmental, health, social, and institutional problems are likely to impose serious constraints on implementation of ERDA's programs, much better integration of these concerns into the pursuit of the technology programs themselves is indicated.

At this time, the adequacy of air quality regulations concerning sulfur dioxide is being questioned. The complex interaction between sulfur oxides and other constituents in the atmosphere, rational and noninduced, is the subject of extensive study by EPA, ERDA, and others. The outcome in terms of sulfate standards for protection of public health and environmental quality is unknown, but could have a serious constraining effect on achievement of ERDA's Plan, which relies heavily on coal in the near and intermediate term. The health programs relating to potential new chemical intrusions from coal conversion and oil-shale programs, some of which may be potent carcinogens should be considered. In the general area of health studies, there is little evidence of a serious effort to define the relative priority between programs. There are also indications that ERDA is involved in programs which do not relate to its energy mission and needs to reassess the usefulness of other programs in terms of the validity of the results these programs will yield.

Existing regulations concerning air and water quality and some which will become effective in the next few years may impose significant energy costs or environmental impacts in categories which are not encompassed by the regulating agency. There has been no systems evaluation of the interactions between environmental regulations and their total effect. This is a valid and important area of inquiry for ERDA which has not been addressed.

There is a significant risk inherent in the totality of ERDA's mission. The impact on climatic balance of massive increases in heat rejection to the atmosphere by man is unknown but potentially catastrophic. There is an urgent need for careful analysis by ERDA of global meteorological consequences of the atmospheric impacts (heat, CO_2, particulate matter, etc.) from the processes it proceeds to develop.

The problems of water availability for coal conversion to liquid or gaseous fuels, shale oil retorting, electrical generation by any means and other energy oriented activities will have to compete with other uses for water in water-short areas, These same activities and associated mining and waste management operations may impact water quality in the same areas, thus potentially affecting agriculture and domestic and municipal water supplies. There are serious questions concerning the impact on air quality of the addition of new energy facilities to the existing field of air pollution sources. These problems indicate an urgent need for a strong regional and site-specific component in ERDA's systems modeling and data acquisition program.

Chapter I

Overview Issue Papers

A. OVERVIEW TASK GROUP

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C. INTRODUCTION

Plans and Programs

Ideally, energy R&D programs should be derived from R&D plans which, in turn, should be derived from a national energy policy. National energy policy, for its part, should flow logically from a set of broad national goals agreed upon b y both the Administration and the Congress. In practice the formulation of energy programs does not operate in such a tidy, rational way, It is reasonable, however, to expect that energy R&D programs be consistent, or at least compatible, with R&D planning and with energy policy in general. Thus, potential effectiveness, rather than perfection, has served as the standard for this review of the ERDA Plan, Using this standard, the OTA analysis produced the following consensus about the ERDA Plan and Program:

- Volume I of the ERDA Plan represents a serious and praiseworthy initial effort to formulate a procedure whereby energy R&D can contribute to the realization of the five goals postulated as guidelines for national energy policy.
- Volume 11 of the ERDA Plan and Program is markedly inferior to volume I and does not always present a convincing programmatic approach to realizing the objectives set forth in volume I.

The lack of coordination between the plan of volume I and the program of volume II was cited repeatedly by ERDA administrators during the oral presentations at the OTA review, The Plan was prepared in the spring of 1975, in the context of ERDA's still-evolving definition of its role and mission. Because of the short time available to ERDA personnel for the preparation of the Plan, the program plans of volume II appear to have been compiled from those of several organizations folded into ERDA. Therefore, they do not properly reflect the policy goals set forth in volume 1. The effectiveness with which ERDA will relate its programs to its plans, and its plans to national goals should improve with the plans and programs that will evolve in the coming years.

A major objection to the Plan is its reliance on a very limited range of scenarios. There is no investigation of the effects of price on the demand for energy services, If the international oil price or policy affecting low cost supplies change drastically, clearly the demand for expensive new low cost supplies change drastically, clearly the demand for expensive new energy technologies will also change. A high priority for ERDA in future versions of the Plan should be to link energy demand to economics,

Goals

The ERDA Plan addresses 5 national policy goals. Realization of these goals requires that inherently difficult choices be made between international cooperation and domestic self-sufficiency as well as between environmental versus energy emphasis, These conflicts appear to have led ERDA to a very narrow, technological interpretation of the 5 goals. For example, the first goal is apparently the most important as the major thrust of the Plan is to minimize reliance on imported oil, This is to be done by vastly increasing domestic supplies. An alternative approach would be to store sufficient supplies of petroleum to make an embargo ineffective and striving to reduce our growing dependence on energy. In addition, the ERDA Plan places little emphasis on programs addressing regional issues; it also neglects to identify programs which might facilitate the implementation of technologies, such as commercialization strategies, end-use conservation technologies, macrosystem modeling, and international institutional development. Each of these subjects falls within the purview of the 5 goals and the ERDA enabling legislation. Whether or not ERDA assumes responsibility for these broader *R, D&D* issues, there can be no question as to their importance to the evolution of a national energy posture, Solutions to our national energy concerns require that those energy-related programs reemphasized by ERDA be vigorously pursued somewhere in the Government. Most are not, at present, receiving priority attention anywhere.

"Is ERDA's role to develop technologies or to solve problems?" was a basic question asked by the OTA task groups. In general, it was agreed that the ERDA programs are too narrowly defined and that ERDA appears primarily concerned with developing technological options rather than exploring solutions to energy problems. This hardware orientation has the following consequences:

- International cooperation receives minor emphasis as compared to domestic self-sufficiency.
- Environmental concerns receive minor emphasis as compared to energy development,
- Elaborate technology is favored over simpler technology,
- Supply technology is favored over end-use technology.
- Technical R, D&D is favored over non-technical R, D&D.
- Demonstration projects in partnership with energy suppliers are favored over projects with energy consumers.
- Mid- and long-term results are favored over short-term results, except for certain energy conservation programs.
- Electrification options are favored over other options.

As we move to diversify energy supplies and increase efficiency, a number of elaborate technologies will be developed; these will result in large-scale projects such as breeder reactors and central station solar electric facilities. However, many of our most promising opportunities are smaller in scale. Examples are solar water heaters, electricity peak shaving, and modified transportation systems. Large and sophisticated technologies have inherent appeal, especially to scientists and engineers, while "low technology" opportunities may seem mundane. ERDA should therefore maintain a program focus which continually measures relative economic and energy benefits, not merely technological accomplishment, as its objective, Success in developing technological capabilities alone is not likely to solve energy problems.

In order to avoid the bottlenecks that will delay or prevent solutions to energy problems, especially in the short-term, a variety of actions could be considered:

- The scope of ERDA's mission could be expanded and clarified, particularly in the areas of demonstration and commercialization, Central to this is a clarification of ERDA's responsibilities vis-a-vis the Federal Energy Administration, the Environmental Protection Agency, the Nuclear Regulatory Commission, and the Department of the Interior,
- Widespread utilization of newly developed technologies depends on a complex process involving the removal of constraints on commercialization, industrial incentives, and technology transfer, This process requires further delineation than exists in the present ERDA Plan.
- Programs associated with the identification and evaluation of environmental, institutional, and societal constraints associated with alternative energy technologies should receive immediate and substantial attention,
- Programs directed toward increasing the efficiency of energy use should be accorded the highest priority.
- New efforts to assess global issues associated with energy, such as climate modification, international energy supply and demand estimates, the role of multinational energy corporations, and the link with ocean resources, should be instituted.
- The ERDA management approach, including the management of National and Federal laboratories and the role of contract R, D&D should be reevaluated.
- Closer working relationships with State and local governments, including their participation in ERDA program planning, should be established.
- The potential national benefit from higher ERDA budget levels should be examined. The present ERDA budget derives from preembargo assumptions which are highly questionable at the present time.

Institutional Issues

The OTA review of ERDA's Plan and Program identified the problem of divided or uncertain jurisdiction as a major concern. For example, responsibility for developing technologies to remove sulfur from coal is divided among Interior, EPA, and ERDA. Similarly, coal mining technologies are the responsibility of the Department of the Interior, while burning and processing technologies are ERDA's responsibility. This situation of split responsibilities inhibits development of a comprehensive and balanced R, D&D program for coal.

Uncertainty concerning the roles of ERDA and FEA in providing incentives for commercialization of new technologies poses problems. Incentives may range from provision of capital for commercial demonstration plants to loan guarantees to insuring floor prices for fuels produced from pioneer commercial plants. If the various types of incentives are divided between ERDA and FEA, orchestration of the most appropriate incentive package for commercialization of a given technology will be difficult. This issue might warrant specific attention as the Congress considers extension of the FEA enabling legislation. Moreover, institutional issues permeate the whole question of the separation of energy R, D&D from the broader responsibility for energy policy which is presently divided among numerous agencies, Although the Congress has designated ERDA as the lead energy R, D&D agency, the ERDA Plan indicates a timidity as to accepting this role. It is not clear that the ERDA Plan and Program provide for effective coordination with other Federal agencies. ERDA could be more assertive in assuming the lead role, in order to assure that the R, D&D needed to achieve the Nation's energy goals and objectives is undertaken.

Marketing and Commercialization

Because of the long lead times and high capital costs involved, special attention should be given to commercialization of new technologies. The energy market is complex, ranging from the individual consumer to large industrial facilities. The market for energy R, D&D is different from that supported by DOD and NASA, both of which provided the markets for their own R, D&D. Similarly, the R, D&D of the AEC was aimed at a specific market consisting of the large-scale electric power industry.

The broad responsibilities inherent in ERDA's programs call for an approach that involves both producers and consumers from the initiation of program planning. R, D&D should reflect ultimate consumer preference and conditions of use (e.g., convenience, acceptable environmental impacts). The phasing from R, D&D to commercialization (usually by private enterprise) must take such issues as proprietary rights, patent rights, and licensing into careful consideration.

Resource Constraints

The various energy technologies addressed in the ERDA Plan frequently draw upon resources which are also in demand for nonenergy uses. It appears necessary that these multiple use factors receive greater priority than they were accorded in the Plan and Program. Although the ERDA Program emphasizes fuel resource constraints, there are actually two categories of resources whose availability could constrain ERDA program developments: physical and societal, The physical resources include water, land, raw materials, equipment, and atmosphere. Of these, water appears to pose the most urgent physical problem, particularly in the western United States. Societal factors which may constrain energy developments include manpower constraints, regional impacts, capital and financing availability y, and information collection, processing and dissemination.

Supply Versus Conservation Balance

Lack of concern with end-use efficiencies developed during an era of decreasing energy prices. At current prices, it pays to shift to a system of much more efficient energy use. Although this will require years to achieve, it will have the ultimate effect of greatly stretching out energy resources. Hence, energy conservat ion will not only help "buy time" in the near-term (the ERDA emphasis) but also dramatically reduce the rate at which resources are consumed in the long-term future. Furthermore, improved energy efficiency has distinct and permanent environmental benefits.

Unlike supply expansion, some conservation improvements can be made quickly and with minimum investment. However, many of the achievable and cost-effective improvements will require R, D&D, Unfortunately, the ERDA Plan for conservation focuses on the near-term and thus neglects its long-term importance, It implies an emphasis on conservation (principally higher efficiency of use) only until new supplies come on line, thus ignoring the potential of a long-term efficiency improvement program. Funds committed to conservation, as opposed to supply increase, are out of balance in terms of (a) cost-effectiveness; (b) time until payoff; (c) environmental benefits versus cost; and (d) demand on resources. ERDA also pays insufficient attention to research related to implementing known energy conservation technologies.

Global Issues

One of the five national policy goals listed in ERDA's Plan is "to contribute to world stability through cooperative international efforts in the energy sphere." Clearly ERDA has to take the world community into account if its Plan and Program are to succeed in the long run. International cooperation is essential in the short- and medium-term to cope with the environmental effects of energy technologies such as global pollution of air and water; to address security issues arising from the management of nuclear materials and wastes; and to manage resources, such as the oceans, that are the common heritage of mankind. Finally, cooperative efforts in research programs can take advantage of substantial advances in certain energy technologies achieved in other countries.

Basic Research

ERDA's inherited programs in basic research need reorientation in order to conform more closely with the ERDA Plan. Such reorientation should not damage the vitality of existing programs such as particle physics. Rather, other basic energy research needs should be defined. Specific attention should be focused on the appropriate distribution between ERDA in-house (i.e., National laboratory) and contracted research; strengthening of social and behavioral research programs; and establishment of an effective role for universities.

Relations to State and Local Governments

The ERDA Plan neither describes mechanisms for incorporating state and local inputs into program development nor shows any indication that these groups were consulted during the preparation of the Plan; these omissions suggest that State participation in energy programs may be restricted primarily to the implementation phases. The ERDA Office of Industry and State and Local Government Relations is much too small to ensure effective coordination between the Administration and the various State and local governments,

ERDA and many of the State and local governments differ in their perceptions of energy problems and in approaches to solutions. The State and local governments tend to attach more importance to conservation efforts than ERDA; they are more concerned with the potential impact of energy R, D&D projects on local communities; and they have greater concern for states-rights issues, including the allocation of water rights and the regulation of land use, The smaller jurisdictions could also benefit from the broader viewpoint that ERDA can provide.

Failure of ERDA to adequately consider State and local viewpoints and to include these agencies in early program planning will result in unnecessary conflict and costly delays in the implementation phases of these programs. More importantly, such failure will limit the Administration's ability to take advantage of these groups' experiences and capabilities in the areas of land and water rights management, taxing and regulatory incentives, manpower training, mobilization of public support, and many other areas vital to program success.

ERDA Budget

Finally, the ERDA budget is largely an outgrowth of decisions made in 1973, before the OPEC embargo led the United States to emphasize self-sufficiency. This budget, about $10-15 billion over a 5-year period, deserves reexamination in the light of the much greater urgency now accorded the energy problem. ERDA could usefully develop alternative 5-year budgets at several specific levels (e.g., $20 billion, $30 billion and so forth) as a device to stimulate new thinking and to assist ERDA in breaking out of established patterns of designing R&D programs,

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 $20 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 Administration, Environmental Protection 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 attention,

- 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 non-technological 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.

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- 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 10 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 implementa- t 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 incen- tivization 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.

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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.

Chapter II

Fossil Energy Task Group Analysis

A. FOSSIL ENERGY TASK GROUP

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B. FOSSIL ENERGY TASK GROUP ISSUES LIST

13. Environmental, Social, and Political Impacts of Mining 74

Even if mining technology is adequate to support an expanded use of coal and oil shale in the United States, there are potential obstacles associated with environmental, social, and political impacts of a massive increase in mining.

14. Manpower ..****..******.***** 76

ERDA's program for massive expansion of the use of coal will require far more trained personnel at various levels than can naturally be expected to enter those sectors of the labor market.

15. Transportation Systems 78

The application of fossil fuel technology research will require improved transportation systems in the United States.

16. Water Availability 80

ERDA has not established a systems-oriented study of water availability related to its energy program.

C. INTRODUCTION

Since ERDA has been in existence for only a short time, its plans relating to fossil energy have had to be developed very quickly. This is a formative period in the creation of a balanced energy program, pressured by the urgency of decreasing the national dependence on external sources of fossil fuel and by the decline in domestic resource oil and gas. Given the substantial challenge of formulating a balanced strategy under these conditions, the ERDA program in fossil energy is a good first effort. There is an obvious need, however, for continued planning and improved analyses of alternative strategies, and the following observations are made in the hope that they can contribute to this ongoing planning process in a positive manner,

The Plan lacks a clear and consistent identification of priorities— It is clear that there is a strong need for some form of systematic, across-the-board optimization of energy programs on the basis of agreed-upon criteria. Congress has requested that ERDA develop such a capability and base its decisions on it. The present ERDA plan (vol. I], however, is merely an indication of the possible consequences of representative alternative strategies. The "national ranking of R, D&D technologies" cannot be used as anything more than an illustration, and the relative funding levels of different programs discussed in vol. II of the ERDA Plan must be determined in some other manner.

One striking feature of the fossil energy program is the absence of a clear priorities list of the various technologies being pursued. The rationale for this absence is that many of its research and development programs lack sufficient information to make critical assessments of the alternative strategies. ERDA has apparently made the decision at this early stage to keep open all options that hold any promise at all of having a long-term payoff. Although funding in the fossil energy program appears to be sufficient to pursue this strategy at present, the situation will change radically when the costs of the program mount in later years. Demonstration and commercialization will require significantly increased funding and will force hard decisions with regard to competing alternatives. It is important that ERDA move swiftly to build the necessary decisionmaking capability.

In deciding priorities, the substitutability of one fuel for another is an important consideration. To what extent can electricity y based on coal combustion (or systems other than fossil fuels) substitute for liquid and gas fuels? What are the needs of industry for liquid and gas feedstock? In what cases can low-Btu synthetic gas substitute for natural gas in industry? What are the economic and social costs of a conversion from one product to another? What are the likely time lags? The answers to questions like these will have a major impact on the relative needs for different fossil fuel R, D&D programs in ERDA. Issues 1, 4, 9, 10, and 11 discuss specific cases of the lack of clear priorities.

The Plan lacks a sense of urgency about increasing energy supplies from domestic resources—By focusing on new technologies, the fossil fuel program (contrary to the supply projections contained in it) limits itself to an insignificant impact on energy supplies in the short term—before 1985. The first priority should be to get better information about presently available technologies and to facilitate their use where feasible: primary oil and gas recovery from new sources (especially, the Outer Continental Shelf), enhanced recovery of oil, pipeline gas from coal, and shale oil from surface retorting. Although the economic feasibility of many of these technologies is highly uncertain at present, the promise of second generation technologies is seldom much brighter. In the meantime there is a need for better information about the impacts, economics, and operating experience of commercial-scale operations. It must be recognized that the era of abundant cheap energy is over—especially in the cases of liquid and gas fuels. Issues *2, 3, 4, 5, 6,* and 9 express concern about the urgency of the energy supply situation.

Demonstration plants should be the keystone of the fossil fuel technology R, D&D program— Because of the urgency of the national energy" situation, the ERDA fossil fuel program should emphasize the demonstration of available technologies at a scale appropriate to their stage of development: near-commercial scale for cases where no serious technical obstacles exist (such as high-Btu gas and possibly oil shale with surface retorting), pilot scale for cases where technical problems still need to be solved (such as tertiary recovery of oil, stimulation of tight gas formations, coal liquefaction, and low-Btu gas-combined cycle powerplants). Although the opinion that emphasis should be placed on demonstration plants for several technologies is not universally espoused, it is not just an industry view. Environmental specialists and university representatives join in the call for better, and more universally credible information about alternatives.

An unresolved question is the possible impact of the proposed national synthetic fuels commercialization program, If this is approved and implemented, its impact on the development of fossil fuels would be substantial, As part of the review of the ERDA programs in fossil energy, Congress may wish to clarify the status and effects of the proposed program in synthetic fuels commercialization, Issues 3, 4, 5, 6, and 10 discuss specific technologies,

Constraints on the commercial application of fossil fuel technologies are given insufficient emphasis in the plan—While fuel technologies are discussed in some detail by ERDA, too little attention appears to have been directed towards the broad range of impediments that can seriously delay, if not block altogether, the introduction of otherwise economically viable technologies. Institutional constraints must be addressed early if the technologies upon which ERDA is concentrating its efforts are to be brought to commercialization. It is poor planning, for example, for ERDA to pour large amounts of funds into the development of a commercially feasible technology for coal liquefaction if the technology cannot then be used—because coal mines cannot supply the coal due to inadequate transportation facilities, capital is unavailable, or water is insufficient, The efficient use of ERDA's R, D&D funds requires a systematic look at entire energy development systems, The fact that ERDA does not have the primary responsibility within the Federal Government for dealing with some of these constraints is not a sufficient response; all the more reason exists in such cases for concern that the Government may not adequately consider some components which are vital for the successful introduction of new technologies, In later plans, perhaps ERDA will assume the lead role assigned to it by Congress and formulate a broad interagency approach to all aspects of fossil energy problems, thereby providing the assurance that important factors impeding development are not overlooked. As with the technologies themselves, a key consideration in dealing with constraints is the need for information that will be accepted as a basis for discussion by groups in society with varying viewpoints. This is especially important—and especially difficult—in assessing the effects of technologies on environmental and social systems, and it emphasizes the importance of undertaking appropriate studies now. Issue papers 8, and 12 through 16 treat these questions in more detail,

D. FOSSIL ENERGY ISSUE PAPERS

1. Fossil Energy Objectives

ISSUE

Almost all of ERDA's programs in fossil energy contain unrealistically optimistic projections of the energy supplies that can be realized from new technologies in the near term.

SUMMARY

ERDA's objectives for 1985 call for 13 to 15 Quads* of fossil energy derived from new technologies. Institutional, environmental, and other nontechnical constraints aside, these objectives cannot possibly be met for the single reason that the time necessary to develop and demonstrate new technologies and to construct a commercial industry based on those technologies exceeds the 10 years between now and 1985. The lack of consistency between ERDA's overall plan in volume I and the specific program projections in volume II raises questions concerning the process by which the objectives were defined and the use served by the objectives in establishing priorities.

QUESTIONS

1. How did ERDA arrive at its objectives for the amount of energy derived from fossil resources?

z. Why are the objectives different in volumes I and II of the ERDA Plan?

3, What purpose is served by the objectives? How have ERDA's programs been determined from these objectives?

BACKGROUND

In volume II, Program Implementation, ERDA specifies the following energy supplies to be made available from new technologies by 1985.

Direct coal combustion (fluidized bed)	1 Quad
Enhanced oil recovery , , ...	2.9 Quads
Stimulation of gas formations	3 Quads
Coal gasification	1 to 3 Quads
Coal liquefaction	(at least) 5 Quads
In-situ recovery of shale	0.1 Quad
Total	13 to 15 Quads

If realizable, this increase would represent a truly major contribution to U.S. energy supplies, as it would constitute approximately 2o percent of the country's current annual consumption,

In volume I, Chapter VIII, however, ERDA lists the following as objectives:

Oil and gas-enhanced recovery	over 6 Quads
In-situ oil shale , ...	up to 2.5 Quads
Coal-direct utilization	over 6 Quads
Gaseous and liquid fuel from coal .	beginning in 1985

*A Quad is defined as 1 quadrillion Btu's.

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Obviously, disparities exist between the two sets of objectives. While the figures for enhanced oil and gas recovery are comparable, those for direct coal utilization and for synthetic fuels are not, As a consequence, the methods used to assign these objectives and their influence in determining the priorities and direction of programs seem to be compromised,

Whatever the origin of these stated objectives, they cannot be considered reasonable in the light of current commercial development. In the opinion of the experts consulted by OTA, the ERDA projections are unrealistic and cannot be achieved with any reasonably designed national energy R, D&D policy. In almost all areas, the arguments are similar. The technology first has to be proved through development and demonstration stages; then a commercial industry must be built to provide the energy. In the case of enhanced oil and gas recovery, field-pilot tests may take five years or more; a similar period is required to begin to produce significant new supplies. Tertiary recovery of oil and stimulation of tight gas formations do not have quick payoffs. Although a proven technology exists for coal gasification, a large commercial industry cannot begin until the economics of the process have been verified. Coal liquefaction is even further removed from commercialization, as is the introduction of pressurized fluidized bed combustion for direct coal utilization. In the near-term, the energy self-sufficiency of the country cannot be based on ERDA's stated objectives for energy supplies from new technologies in fossil fuels.

2. Primary Oil and Gas Recovery

ISSUE

No Federal agency is engaged in a comprehensive research program for primary oil and gas recovery from new sources; the absence of such a program could lead to delays in the development of these resources.

SUMMARY

Exploration and development of oil and gas from new sources, particularly the Outer Continental Shelf, continues to be severely delayed by the lack of planning on the part of the Federal Government. An aggressive ERDA research program would complement industrial efforts. In particular, research is needed on the effects of offshore drilling and on ways of mitigating those which are harmful to the environment. Congress mandated in Public Law 93-577 Sec. 6(b)(3)(Q) that ERDA engage in a program to explore methods for the prevention and cleanup of marine oil spills, but the scope of ERDA's proposed activities is not clear.

QUESTIONS

1. What is ERDA's current schedule for development of the congressionally mandated program on methods for the prevention and cleanup of marine oil spills?
2. What current studies of regional, social, and economic impacts of Outer Continental Shelf (OCS) exploitation is ERDA performing (or monitoring if being performed by other agencies)?

3. What are ERDA's plans for development of a coherent information base to assist potentially impacted areas in coastal zone planning for OCS oil and gas development?

4. What studies are underway at ERDA or in other agencies with which ERDA is cooperating on alternative OCS oil and gas lease management arrangements and compensation provisions in the event of adverse impacts on areas of OCS oil and gas development ?

5. How soon does ERDA anticipate having a comprehensive data base on site-specific environmental conditions of potential OCS lease areas? If the regional data are to be assembled by an agency other than ERDA, what is ERDA's current role in defining the nature and extent of information to be acquired and the time schedule for the program?

BACKGROUND

There are three sources of large quantities of liquid and pipeline gas fuels from domestic resources in the near-term (to 1985): production of oil and gas from the onshore lower 48 States, offshore sites, and Alaska. Estimates of petroleum resources on the OCS (to a water depth of 200 meters) range between 10 and 130 billion barrels (20-50 percent of U.S. resources); OCS natural gas resources are estimated at greater than 100 trillion cubic feet (20-30 percent of U.S. resources). Most of the present production is taking place in the Gulf of Mexico, but there are also sources of oil and gas off the Pacific coast, the Atlantic coast, and the coast of Alaska. Although development in some of the promising areas would be hampered by severe environments, there are no serious technologic obstacles to extracting oil and gas. The basic technology has been well-tested in the Gulf of Mexico, the North Sea, and elsewhere.

The expansion of offshore production to increase domestic fuel supplies has recently been very slow, mainly because of environmental and institutional obstacles. In particular, the problem stems from an inability to lease promising development sites because of public opposition due to uncertainties about environmental and social impacts.

One way to remove development delays is to reduce the likelihood of environmental damage from oil spills by developing better blowout prevention and cleanup technology. In the long run, this would reduce uncertainty and should help to avoid delays in opening up new areas for production. In the short run, and especially over the next several years, other Federal activities are needed as well. Research requirements include the following:

- Geological information on new potential oil and gas resource regions.
- Site-specific studies of environmental conditions well in advance of lease sales.
- Research on the prevention and consequences of oil spills.
- Studies of the regional social and economic impacts of OCS exploitation and possible frameworks for compensation for adverse impacts.
- Support of coastal zone planning.
- Development of alternative lease management arrangements.

The Congress directed ERDA to engage in a program to investigate methods for the prevention and cleanup of marine oil spills. (Public Law 93-577, Sec. 6(b)(3)(Q)), but it is not clear how much of an effort is proposed as part of the Environmental Control Technology program of ERDA—the only place in the ERDA Plan where oil-spill cleanup is treated.

3. Enhanced Oil and Gas Recovery

ISSUE

The proper role for ERDA in enhanced oil and gas recovery is not well defined.

SUMMARY

Enhanced recovery of oil and gas from known reserves holds promise of significantly increasing the supply of these fuels. The need for research and development in the area of enhanced recovery clearly exists, but opinions differ as to the proper role of Government in this endeavor. The present pace of industry R&D could be accelerated by formulation of a detailed workable incentive plan. The present ERDA tertiary recovery program for oil, which involves special joint Government/industry field-pilot testing and demonstration, and the similar research on the recovery of gas from tight formations, will not yield a significant increase in production by 1985. ERDA's projection of an additional annual increase of approximately 6 Quads resulting from enhanced recovery is therefore unrealistic.

QUESTIONS

1. On what basis did ERDA make the projection of 6 Quads input to U.S. energy supplies from enhanced oil and gas recovery by 1985?
2. What is ERDA presently doing to ensure that tertiary methods for oil recovery are brought to commercial application in the shortest possible time and with maximum potential for application over the entire U.S. oil production industry?
3. What would be the effect on gas supplies in the 1985-90 period of an increase in Government funding for research on tight gas formations from $5 million to $25 million per year

BACKGROUND

Owing to the convenient form and relative environmental attractiveness of crude oil and natural gas as domestic resources, it is important that the United States extract and use what it has. In fact, the necessary pace of development of synthetic liquid and gas fuels depends largely on the amount of oil and gas that can be recovered. This amount depends partly on the ability to tap sources like shallow oil beds, oil that remains in developed oil reservoirs (secondary and tertiary recovery), and oil that is too viscous to extract with conventional procedures. The National Academy of Sciences has recently estimated that new tertiary techniques might yield 105 billion barrels of oil from old fields. It is obviously important to find out how much is actually recoverable by enhanced oil and gas extraction techniques, an amount dependent partly on the state of technology.

Tertiary recovery methods—as distinct from secondary methods such as water flooding and natural gas injections—include polymer floods, surfactants, miscible recovery processes, immiscible gases and thermal (usually steam) recovery methods. Tertiary recovery methods are at an early stage of development and much work remains, particularly in identification of the most favorable conditions for each method and characterization of the economics and net energy yield from competing methods.

The present ERDA program in enhanced recovery began in 1974 when a joint Government/industry project was initiated between the Bureau of Mines and a private oil company. These experiments are approximately 50 percent supported by the Federal Government. The current program calls for roughly 10 tests of several techniques in different reservoirs over the next three or four years. Three of these 10 tests are currently underway.

Some experts have characterized the problem as one of testing and centralizing information on a variety of techniques (four or five basic types) in a number of reservoir types (perhaps 30 or 40). This process would require a total of 80 to 150 experiments. The total cost of such experiments is estimated at $300 to $400 million. Assuming that half of the cost is borne by the Government over a 4-year test period, the Government cost would be $40 to $50 million per year.

Many support ERDA's present tertiary oil recovery program. On the other hand, critics of the program contend that direct Federal involvement is unwarranted on the grounds that industry can be motivated to develop the necessary technology on its own. However, sufficient price and other incentives would be necessary, since production costs of enhanced recovery are expected to be high.

Expertise in enhanced recovery resides principally with industry, which has already invested heavily in the needed R&D, As the incentive approach does not require the release of proprietary information, it is likely to appeal to industry. However, this factor may also be regarded as a disadvantage, as it may deprive nonparticipating oilfield operators of valuable data, Nevertheless, it is possible that a broad industrywide incentive program could initiate more research and development than a limited number of federally funded projects.

General agreement is that testing of a large number of reservoirs must be pursued. Until a detailed, workable incentive plan is formulated, the present R, D&D program undertaken by ERDA, though insufficient, will yield at least some of the necessary information. In addition, because the stimulation of tight gas reserves involves greater risks than enhanced oil recovery, direct Federal participation in a program to develop these reserves is warranted; ERDA's program in this area is reasonable.

It should be noted that no significant increase in production can be expected by 1985, because of the time required to complete and evaluate enhanced recovery methods for gas and oil, The annual increase projected by ERDA of 2.9 Quads from oil via enhanced recovery is thus unrealistically optimistic.

Similarly, the anticipated increase of 3 Quads from the enhanced recovery of natural gas is unrealistic. The Western United States contains an estimated 600 tcf of natural gas locked in tight rock formations, but there is no developed, economically feasible technology to produce the gas. R, D&D is expensive and too risky for industry to participate independently on a very large scale. Massive hydraulic fracturing and other nonnuclear fracturing methods are currently considered the most promising approaches, taking into account technical, environmental, and social factors, If a chance of using these resources to meet gas fuel demands by 1990 exists, an accelerated research program is needed, but because of the uncertain prospects of success such a program is unlikely to be undertaken by industry. The proposed ERDA budget includes $5 million for R&D on tight gas formations in FY 76. A comprehensive accelerated R&D program, however, would require $20 to $25 million a year. That sum would provide the necessary funds to perform 15 experiments lasting about 4 years and averaging about $6 million a piece.

4. Oil Shale Processing

ISSUE

ERDA's priorities for oil shale R, D&D lack a sense of urgency in meeting the Nation's energy supply needs in the near- and mid-terms.

SUMMARY

ERDA's programs for oil shale development are concerned exclusively with in situ processes, but these processes will make no contribution to liquid fuel supplies in the near-term and have uncertain prospects for the mid-term. The ERDA conclusion that the above ground processing of oil and shale is not economically feasible (or has no need for Federal R, D&D support) has no basis in operating experience. An oil shale demonstration program based on available technologies is needed.

QUESTIONS

1. Why does ERDA's oil shale program fail to include support for demonstrations of surface retorting technologies?
2. What led to the emphasis by ERDA on the Bureau of Mines horizontal in situ retorting concept rather than modified in situ processes or vertical retorting concepts?
3. How serious are the problems of waste disposal and water consumption for surface retorting processes?
4. What basis is there for being optimistic about the projects for in situ gasification of oil shale?
5. How adequate are waste management procedures for the disposal of spent shale?

BACKGROUND

The Administrator of ERDA is mandated, in Public Law 93-577, Sect. 6(b)(3)(G) to "assign program elements and activities. . . (which) shall include. . , research, development, and demonstrations designed. . . to demonstrate the production of syncrude from oil shale by all promising technologies, including in situ technologies." The ERDA Plan includes programs to develop and demonstrate in situ recovery to produce shale oil, but no program at all for above ground research on oil shale production and retorting to shale oil. The ERDA document claims that "adequate technology exists for conventional mining and surface retorting of shale, but the economics of surface processing are marginal at best."

It is appropriate that ERDA should devote considerable effort to in situ shale oil production methods, because of the reduced environmental impacts of this technology, but not to the exclusion of mining and above ground retorting. There is no assurance that a satisfactory and economically competitive in situ technique can be developed. Even among the range of in situ extraction concepts, the horizontal technique, which receives the greatest emphasis in 'the ERDA budget, appears to carry a higher risk of failure than other techniques which are at least as far along in development. ERDA's proposed program for producing gas rather than oil from shale is an even longer term option than producing oil and has potentially serious additional problems; yet this option is supported in the budget, while above ground oil retorting alternatives do not appear in the program. If ERDA has valid reasons for taking this course of development, then better justification should be given for the programs that have been proposed and reasons given for exclusion of other approaches that many consider more promising.

Presently, no commercial above ground oil shale is processed in the United States. It appears that private sector investment sources are unwilling to accept the risks associated with a pioneer commercial facility. The several private projects which currently exist are still at the pilot retort stage. The critical problems associated with shale oil include mining technology for shale extraction, the economics of the total activity, and the management of waste in the form of spent shale. No commercial activity has had to cope with the mining and waste management problems at the level which would be created by a commercially viable shale oil plant, A commercial-scale facility can provide a broad range of opportunities to test procedures, prove technology, and train manpower in the special skills which must be developed. This is an appropriate subject for ERDA involvement at the demonstration level.

5. Synthetic Liquid Fuels From Coal

ISSUE

New and existing projects in coal liquefaction must be carried through the pilot and demonstration stages in order to determine what technical problems remain and to establish the oil price levels at which commercial production will occur.

SUMMARY

Justification of the coal liquefaction program rests primarily on the decline in U.S. oil production and on the need for supplies for those uses of liquid fuels for which there is no ready substitute. A successful commercialization program in the 1980's depends on the results of pilot projects, The existing and proposed development programs of ERDA are judged to be of the proper magnitude and in the correct direction. However, the constraints to commercialization, such as the capital investment, construction time, and development of associated mine facilities imply that the projection by ERDA of 5 Quads per year cannot be overcome by 1985. Thus, ERDA's projection that coal liquefaction will significantly affect fuel supplies by 1985 is-unrealistic.

QUESTIONS

1. How did ERDA arrive at a projection of 5 Quads per year of energy from coal liquefaction by 1985?
2. How serious are the environmental and health problems associated with the use of synthetic liquid fuels from coal likely to be? Are the hydrocarbons likely to be carcinogenic? Is chemically bonded nitrogen a problem?
3. What has ERDA done to determine the economic and commercial viability of the product ion of methanol as directed by Congress in Public Law 93-577?

BACKGROUND

Given the growing disparity between the ability of the United States to produce oil and our consumption of this fossil fuel, it is necessary to consider seriously how either the supply and/or the consumption of oil can be modified in ways least likely to do damage to society. Whereas replacement of oil by another fuel (coal) for direct heat and electric power generation is relatively straight forward, in principle, there presently exists no viable substitute for oil used in transportation, particularly in automobiles and aircraft, and chemical feedstock. By restricting oil to uses for which no other alternatives exist, the United States could extend its reserves of oil and provide a longer period to work on possible long-term solutions to the transportation problem. However, the development of an economically competitive synthetic liquid hydrocarbon derived from coal would introduce a valuable alternative strategy to counterbalance the decline of domestic oil supplies.

The technology for coal liquefaction developed during World War II is not directly applicable to economic commercialization under present conditions. Several second generation processes for producing liquid hydrocarbons have been shown to be technically feasible in small-scale testing. Data and experience to date, however, are too rudimentary to permit a prediction as to which, if any, of the several processes can yield a product for large-scale use at an attractive cost. The probability of payoff is sufficiently high, however, to warrant proceeding with a broadly based program. The orderly progression of this technology necessitates continuing it through the pilot and demonstration plant stages. In this regard, three projects are currently in progress: the H-Coal and Synthoil Pilot projects involve direct, high-pressure catalytic hydrogenation, whereas the Coalcon demonstration project covers a version of low-temperature carbonization under hydrogen pressure, These programs should be continued as long as results are promising.

Existing additional approaches to coal liquefaction should also be funded at a demonstration plant level of sufficient size to permit scale-up to a commercial plant. Two-stage "hybrid" liquefaction processes involving extraction followed by hydrogenation are sufficiently well understood to warrant the step up to this plant level. Given the large number of variants of this process being tested on a small scale, two such projects may be justified. If a viable process is identified, it should be possible to proceed to commercial projects at the 50,000 barrels per day level in the mid-1980's. Such commercial projects would have a small impact on fuel supply in 1985. However, the projection by ERDA of at least 5 Quads per year at that time would require 50 such plants, each involving a capital investment on the order of $1 billion and a construction time of 5 years. The time scale of this ERDA projection is thus totally unrealistic,

Institutional problems do not appear serious in process development at the pilot stage under the present cost sharing procedure of 1/3 industry—2/3 Government, However, on proceeding to commercialization, all the possible problems associated with any process requiring the extraction of large amounts of coal from the ground appear: mineral rights, mining technology, land reclamation, water use, capital availability, and so forth, These problems are discussed in Issue 6 in connection with development of technology for high Btu gasification and, thus, are not repeated here,

6. High-Btu Gasification of Coal

ISSUE

The construction and operation of a first generation, commercial-sized, high-Btu coal gasification plant is a prerequisite to any decision on a coal-based synthetic natural gas industry.

SUMMARY

A pioneer commercial plant, producing 250 million cubic feet per day of high-Btu gas from coal, can be constructed immediately using current technology. Through its construction and operation, the economic, technical, and operating data necessary to assess the desirability of a coal-based synthetic natural gas industry can be determined. The objective of this construction is to determine whether or not high-Btu synthetic natural gas from coal is economically justifiable as a means of using the Nation's coal reserves to replace the declining supplies of natural gas and oil.

While several companies have shown a strong desire to build a commercial plant, they have not done so because of difficulties in financing such a plant, which will cost at least $1 billion, Incentives of some form, such as loan guarantees or regulatory changes, may have to be provided by the Government if the natural gas industry is to build one of these plants,

QUESTIONS

1. What are the reasons for the uncertainty in the cost estimates regarding high-Btu gasification projects?
2. Why cannot a consortium of gas companies provide the necessary financing without Government assistance?
3. Should steps be taken to change the limitations imposed by the Federal Power Commission in granting certification of high-Btu gasification plants?

BACKGROUND

Although the Nation possesses vast coal reserves, they are not infinite, and the capital required to convert coal to useful energy is substantial. Therefore, it is imperative that utilization of coal be as efficient and economical as possible. High-Btu gasification of coal is but one option which must be evaluated. In this regard the construction of a pioneer commercial plant is important for the following reasons:

- Cost estimates for energy-related construction have been notoriously bad. The costs of high-Btu gas, determined from the operation of a pioneer commercial plant, will furnish a valuable basis upon which to make decisions as to whether to proceed with further commercialization.

- The construction and operation of the plant will provide experience in problems associated with the production and handling of massive quantities of coal, with the development of expertise in fabrication of special equipment, and with the training of personnel to operate and service the plant.

Proven technology, based on the Lurgi gasification process followed by a methanation stage, exists today to permit construction of a plant producing 250 million cubic feet per day. Moreover, since less than 25 percent of the total construction costs of plant and support systems is attributable to the gasification process, likely improvements in gasification technology can have only a minor impact on overall costs. There would appear therefore, to be little reason to delay construction in anticipation of such technological improvements.

Industry has shown a clear interest in constructing pioneer commercial plants. El Paso Natural Gas, WESCO (Pacific Lighting Corporation and Texas Eastern Transmission Corporation), and American Natural Gas Corporation have each filed applications before the Federal power Commission for certificates to authorize construction of commercial coal gasification facilities,

The WESCO plant, which has received certification by the Federal Power Commission, was scheduled to be built in San Juan County, New Mexico and deliver 75 percent of its gas to the Los Angeles area, At oral arguments before the Commission on March 14, 1975, the cost of this plant was stated to be in excess of $800 million and the tailgate price of gas was placed at about $2.45 per thousand cubic feet. Although the gas is readily marketable in Los Angeles, several constraints exist which have prevented WESCO from proceeding with the project. The principal problem is that the capital requirements of an individual plant are more than 50 percent of the total capitalization of the company proposing the plant, while the increment added to their gas supply is only about 10 percent of their total volume. As a consequence, financial institutions are unwilling to finance these plants without some sort of guarantee that the venture will recover its costs.

Central to this concern is the cost of the synthetic gas. The estimated cost of a plant with a daily capacity of 250 million cubic feet has increased from $300 million (mid-1972 dollars) to $800 million (January 1975 dollars) and the cost of coal has increased from approximately 20 cents per million Btu to 40 cents per million Btu. As a consequence the estimated cost of gas produced has increased from $1.40 per million Btu to over $2.40 million Btu.

Under the present energy regulatory structure, the only way the gas companies appear able to get financing on the terms they require to build the plants is to obtain Federal Power Commission approval of the cost of service guarantee concept, The Commission, however, has decided that it cannot grant approval and still maintain its responsibility to the public interest. In effect, the FPC has ruled that such a guarantee would allow an open-ended contract which could “escalate beyond the zone of reasonableness” should gas production drop substantially. The Commission has consistently adopted this view on all requests for a cost of service guarantee and has therefore attached a fixed rate to each certificate subject to filings for rate increase under section 4 of the Natural Gas Act,

The Federal Government can provide industry with the necessary incentives to build one plant having a capitalization of approximately $1 billion, in order to be able to determine whether synthetic high-Btu gas from coal is economically justifiable as a replacement for the declining natural gas supply. The best methods of providing these incentives remain to be determined; the Federal Government might, for example, guarantee the company a loan for plant construction as well as recovery of cost of service plus a reasonable return on investment,

The gas industry advocates construction of many—perhaps 20 or more—plants at the present time, on the grounds that the existing investment in gas transmission and distribution systems should be fully utilized. However, the cost of coal gasification may be so high that other options for supplying this energy demand will prove cheaper and, hence, more desirable, A commercial plant, made possible by offering the necessary incentives, would permit development of the data needed to clarify the relative merit of high-Btu gas from coal versus the other options.

7. Low-Btu Coal Gasification for Industrial Use

ISSUE

The ERDA program on low-Btu coal gasification does not give attention to the fuel needs of industrial furnaces, kilns, and ovens.

SUMMARY

Many users of natural gas and oil in the industrial sector (ferrous and nonferrous meta llurgy, glass, lime, cement, refractories, stills, etc.) could shift to low-Btu gas from coal if suitable gas producers were available, This shift would make an important contribution to the conversion from the use of oil and gas to the use of coal, and it would help to ensure against production cutbacks due to curtailments. There is much room for R, D&D supported by ERDA with a focus on assessment of the potential demand for low-Btu gas by the industrial sector, means for increasing this potential through modification of equipment or operations, and the development of gas producers having performance characteristics suitable for modern industrial use,

QUESTIONS

1. How does the potential demand for low-Btu gas in the industrial sector compare with that for use with combined gas turbine/steam turbine powerplants?
2. What fraction of the present use of natural gas and oil in the industrial sector could be shifted in the near-term to low-Btu gas?
3. Would the low-Btu gasifiers being studied by ERDA for other applications be suitable for use in the nonelectrical industrial sector?
4. What steps are being taken to supply fuel for those parts of the industrial sector now facing natural gas curtailments?

BACKGROUND

Gas producers, devices in common use 50 years ago for making low-Btu nitrogen-diluted gas, have almost disappeared from use. They were once used primarily in close coupling to the furnace to which they supplied fuel, thereby allowing effective delivery of the sensible heat content of the hot fuel gas; but they were sometimes used to produce cleaned cold gas. A variety of technical and economic factors led to their disappearance, the most dominant factor of which was the increasing availability of cheap natural gas. With our present declining natural gas reserves and our increasing dependence on foreign oil this situation has changed, and the desirability of again being able to make industrial gas from coal arises.

Although many industrial users of natural gas and oil could shift to low-Btu gas produced from coal if suitable gasifiers were available, the ERDA Plan does not address the problem. This shift to coal by the industrial sector has the potential to make an important contribution to solving the Nation's energy problem in the mid-term,

Since changes in labor, economics, size, environrnenta1 concern, etc., make the old gas producers unacceptable by today's standards, a strong R, D&D program is needed now. Much of the work being carried out by ERDA on low-Btu gasification will have application to the production of industrial fuel, but unless specific attention is given to the industrial sector, its special problems and requirements may be overlooked.

8. Mining Technology

ISSUE

Research on underground mining technology is required if coal production is to double in the next 10 years as projected.

SUMMARY

Government and industry are expecting coal production to double to 1.2 billion tons annually by 1985. To help assure that these projections can be met, coal mining R&D will require priority support. The productivity per miner in underground mines has decreased in recent years, principally because of improvements in health and safety standards; technological progress has been unable to offset the decline. Improvements in mining technology have the potential for making significant contributions sooner than most R&D projects in fossil energy, Although Federal responsibility for coal mining rests with the Bureau of Mines in the Department of the Interior, ERDA has a responsibility to ensure that the research necessary to improve the technology of underground mining of fossil fuel resources is carried out,

QUESTIONS

1. What importance does ERDA place on R, D&D in underground coal mining technology in meeting its objectives for coal use in 1985?
2. What action is ERDA taking in its role as lead agency in energy R, D&D to ensure that the proper programs are in progress on mining technology?
3. What does ERDA view as the major priorities for R&D in mining technology and what are the projected benefits from such R&D?

BACKGROUND

The 1985 coal consumption projections, based on industry and Government estimates, are in the *1.1* to 1,2 billion ton range, of which two thirds are expected to be consumed by electric utilities. To meet 1985 projected demand, coal production capacity will need to be doubled, an increase of 600 million tons capacity in *10* years. In addition, a minimum of *100* million tons of replacement capacity will be required to offset mine depletion or exhaustion, for economic and other reasons.

These large increases must be contrasted with the pattern of the past 5 years, over which total production of all coals remained stable,

Underground coal mining is expected to increase in actual output but to decline as a percentage of total production. Traditional room and pillar mining systems are the most widely employed methods for underground coal extraction. Equipment used is either conventional (mechanical loader, undercutting, wheel mounted shuttle cars, drills, roof bolters) or continuous miner (which eliminates undercutter and drill). To a lesser extent, the longwall system of mining has been introduced as a means of improving recovery, particularly in deeper seams. Expansion of this type of mining has tended to be inhibited by higher capital investment and a degree of inflexibility in layout introduced by the 1969 safety legislation, as well as by downtime experienced during transfers of equipment from panel to panel, Where applicable, the higher production generally offsets the system limitations.

A relatively new system of mining for pitching or inclined coal seams has been successfully introduced in Canada. Hydraulic or jet mining has been used in Russia and Japan for a number of years. There is reason to believe that many of the steeply pitching coal seams in the Western United States can be mined economically by this method. The science of hydraulic mining is not new; however, its application to coal in the United States would be,

There was a significant increase in the work force in 1970 following the enactment of the Mine Health and Safety Act; employment jumped from 124,000 to 140,000 workers. Although production volume has remained stable during the period from 1970-74, the number of miners increased by an additional 10,000 employees to 150,000.

Overall industry productivity declined from 19.9 tons per man day in 1969 to 17.3 tons per man day in 1974. More pertinent is the decline in underground mining productivity from 15.6 tons per man day in 1969 to 11.4 tons per man day in 1974, Strip mine productivity has remained about the same, at 36 tons per man day.

Research and development in underground coal mining technology has the potential of making important contributions to increased productivity and overall production, Advanced scientific and technological developments of the past decade have not yet been transferred to coal mining but hold considerable promise of being applicable,

Research is needed on a wide range of problems:

- high speed mine development to decrease the time necessary to bring new mines into productivity,
- automated longwalling systems to increase productivity through automation,
- machine reliability improvement to reduce delays,
- continuous roof support to reduce the time required for installation of roof support,
- haulage systems to speed the movement of coal from the operating face to the surface plant,
- methods for full extraction from thick and multiple seam western coal,
- control of mine subsidence and waste discharge, and
- preparation techniques for upgrading the quality of coal,

The Bureau of Mines presently has R&D programs covering most, if not all, of these subjects. Assurance is needed, however, that the level of effort in coal mining research is commensurate with the importance of the increased production of coal to meet the Nation’s energy requirements. In reviewing and modifying overall R&D strategies for problems relating to fossil energy, ERDA must cooperate to ensure that improved mining technologies are developed for underground operations.

9. Direct Coal Utilization

ISSUE

ERDA's near-term program for direct coal utilization by utilities and Industry is narrowly oriented toward fluidized bed combustion.

SUMMARY

The use of fluidized-bed combustors with sulfur-absorbing beds to provide gas cleanup is unlikely to make a significant contribution in the near-term (to 1985), as predicted by ERDA, due to technological barriers to implementation, Two major coal combustion problems whose resolution would have major near-term impacts are:

1) the technical difficulties of substituting coal for gas and oil in presently existing utility and industry applications (retrofit), and

2) the direct use of coal in a way which will meet environmental requirements.

Other technologies which hold promise of providing solutions to these problems are pulverized fuel firing, and precombustion cleanup; both of these need research and development support in order to enhance their contribution to direct coal utilization by utilities and industry, There is also a need for more basic research in coal chemistry. The present division among three Federal agencies of responsibility for coal cleanup causes variations in the criteria adopted by the agencies as well as in the size and effectiveness of their programs. By assigning the funds and responsibility for managing these programs to one agency, the development of a balanced coal cleanup program could be facilitated. In all areas, the energy program could be set back by a failure on the part of ERDA to recognize the needs of the industrial sector such as the ferrous and nonferrous metal fabrication industries, the glass and ceramics industries, and manufacturers of cement and lime.

QUESTIONS

1. On what grounds does ERDA exclude R, D&D on improved pulverized coal combustion?

2. What improvements in pulverized coal technology are necessary in order to make this technique a viable option for future coal burning plants?

3. What are the problems to be solved prior to commercialization of pressurized fluidized bed combustion?

4, How do the projected costs for solving the problems in pressurized fluidized bed combustion compare to the costs of achieving improvements in pulverized coal burning?

BACKGROUND

ERDA's program in direct coal utilization is narrowly focussed on fluidized bed combustion. Pressurized fluidized bed technology is probably at least 15 years away from becoming a commercial competitor with present pulverized fuel firing. The arguments for fluidized bed combustion are as follows. The combustion equipment is compact, possibly involving a lower capital cost; the opportunities for cleaning during combustion are great; and the technical understanding of fluidized bed operation at atmospheric pressure will spring-board the development of pressurized fluidized bed combustors. It is postulated that these later generation equipment, by the inclusion of sulfur-absorbing media in the bed, will be an ideal method of providing hot gases to drive gas turbines. The future use of fluidized bed combustors requires the resolution of several technical problems. These difficulties include the product ion of large quantities of waste (up to 300/0 of the amount of coal burned), hot gas cleanup problems, and materials problems associated with boiler tubes submerged in the bed. The emission of sulfur compounds from coal combustion systems must be prevented or reduced in order to make this source of energy environmentally acceptable. Until now, sulfur emission has been controlled by post combustion cleaning, i.e., stack-gas scrubbing. Unfortunately, stack-gas scrubbers are expensive to build and operate, and have been unreliable in use. Alternatives are being sought and the ERDA plan chooses an intracombustion method, i.e., the inclusion of a sulfur-absorbing medium within a fluidized bed combustor, Because of the technical problems mentioned previously, additional options should also be pursued. Precombustion coal cleaning techniques can make a significant contribution toward the reduction and control of sulfur emissions,

Precombustion methods have been in operation since the 1930's in various parts of the world. They fall into two groups; physical and chemical. The former are the most tried and, with some coals, have proved entirely satisfactory in service to remove up to 80°/0 of the sulfur present, although usually less than 500/0 is removed by this technique,

Research is needed to examine other precombustion cleanup methods and to study the fundamental mechanisms of the combustion process.

The division of Federal responsibility among three agencies presents an obstacle to the development of a balanced program in coal cleanup. Presently the Bureau of Mines oversees Government support of R&D in precombustion cleanup, while post combustion cleanup falls within the jurisdiction of the Environmental Protection Agency and intracombustion cleanup has been taken up by ERDA.

Under these circumstances, adequate tradeoff evaluations or balances among these alternative approaches may not occur. Furthermore, the criteria used to evaluate each option vary with the lead agency, and there is no place where the entire profile of criteria (environmental, economic, institutional, efficiency) is applied across the board to all options. Furthermore, the size and effectiveness of programs devoted to each technology by different agencies are likely to be quite variable with no guarantee that the most promising approach will be properly emphasized, It would appear to be desirable to have the funds devoted to these various approaches allocated and managed by one agency even if these funds were then passed to other agencies.

Finally, ERDA's program in fossil fuels must consider the needs of industry, which consumes 40 percent of the Nation's energy. Failure to prepare for industrial needs for an acceptable substitute for oil and gas in existing facilities could lead to reduced production to the detriment of the economy and society.

10. Low-Btu Gasification, Combined Cycle Powerplants

ISSUE

The present ERDA program to develop integrated low-Btu gasifier, combined cycle powerplants has underestimated their potential.

SUMMARY

In terms of both efficiency and economics, the integrated low-Btu gasifier, gas turbine/steam turbine, combined cycle electrical generating system promises to become one of the best methods of using coal in an environmentally acceptable manner that is likely to be developed, Commercialization of such a system, which would have an overall efficiency of 37 to 38 percent (coal pile to bus bar), should be achievable in the mid to late 1980's if a balanced research and development program is conducted. The ERDA documents give no indication that planning for such a program is taking place.

QUESTIONS

1. On what schedule and at what funding level are pilot and demonstration plants for integrated low-Btu gasifier, combined cycle systems included in the ERDA program?

2. What is the schedule and funding level for development work on high temperature turbines for improving cycle performance?

3. What plans has ERDA made for research and development on gas cleanup systems that are applicable to low-Btu gasification, combined cycle systems?

4. Of the different types of pressurized low-Btu gasification, clean gas processes, (e.g., fixed bed, fluidized bed, and entrained bed):
   a. What are the different probabilities of technical and commercial success?
   b. Will the construction of demonstration plants for all three gasification processes be funded in order to assess their relative economics?
   c. What are the probabilities of success of hot gas cleanup versus cold gas cleanup via scrubbing?

BACKGROUND

The lowest cost, environmentally acceptable, coal-fired, base load electric powerplant in the foreseeable future may be an integrated, pressurized low-Btu gasifier, high temperature gas turbine, and steam turbine plant. Such a system could be built today but it would be limited to particular (noncaking) kinds of coal and to efficiencies comparable to conventional coal-fired steam plants. The operating features and requirements of the gasifier and the combined cycle plant complement one another, the turbine producing compressed air and steam for the gasifier and the gasifier producing gas turbine fuel, This integration offers the possibility of significant gains in overall plant energy efficiency and reduction in plant costs by the common use of large major components as contrasted with freestanding fuel and powerplants. There is a clear technical path by which such systems could be developed in stages so as to use a wide variety of coals and reach overall efficiencies (coal pile to bus bar) of above 40 percent, One path which appears to have the least severe technical barriers includes the following developments: (1) improved pressurized fixed-bed gasifier capable of handling caking coals and having higher capacities than today's units; (2) improved gas cleanup systems; (3) plant integration to optimize the synergism between gasifier, gas turbine and steam turbine; and (4) advanced gas turbines with firing temperatures well above 2000° F, growing eventually to near 3000°F.

The integrated low-Btu gasifier, combined cycle system could be developed via no more than two to four generations of precommercial demonstration plants. Each plant would lead to another round of technical advances; the final goal would be achievable in the late 1980's. If the likely technological developments occur, the system may generate electricity at a lower cost as well as more efficiently than conventional coal-fired plants with stack-gas scrubbing and, in addition, would present a minimum of byproduct problems. The system costs would appear to compare favorably with those of a nuclear light water reactor of equivalent size.

A program of the type described above does not appear as a line item in ERDA's Plan. Rather, the technological components of the low-Btu gasifier, combined cycle system are distributed among sever al o f the proposed ERDA programs. The turbine portion of the system appears under "Advanced Power Systems" and "Electric Conversion Efficiency, " while the low-Btu gasifier portion is located under "Coal Gasification." The low-Btu gasification programs would appear to be better placed under "Direct Coal Utilization, Utilities/Industry" since the latter describes their functional objective—quite a different objective from those of the high-Btu and 1iquefac- t ion programs. In addition, the low-Btu gasification program should be carefully watched to take into account progress in advanced turbine development.

11. Advanced Fossil Fuel Combustion Programs

ISSUE

Frequent evaluation of progress in magnetohydrodynamic (MHD) and other high-efficiency energy R&D programs will be necessary to ensure maximum energy yield over the long term.

SUMMARY

The ERDA Direct Coal Utilization program contains both the Direct Combustion (i.e. fluidized bed) and Advanced Power Systems (i.e. gas turbine) programs. MHD research is a separate program, even though MHD is a direct combustion process. Fuel cell R&D is not included in the Fossil Fuel Division of ERDA, though it has more in common with the fossil programs than with the non-combustion Advanced Division in which it is housed. Relative fu ding of these programs indicates heavy ERDA emphasis on fluidized bed and MHD, much less emphasis on advanced gas turbine research and an almost total disregard of fuel cell technology.

A portion of the present ERDA emphasis is well placed, given that fluidized bed combustors and MHD systems can burn coal directly, while the advanced gas turbine and fuel-cell technologies require liquid or gaseous fuels which over the long term will have to come from coal conversion. Thus, while the advanced gas

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turbine and fuel-cell technologies can probably be brought to commercial application much sooner than MHD or pressurized fluidized beds, their fuel deployment will depend on progress in the commercialization of synthetic fuels.

In many applications, these technologies are mutually exclusive. Funding and program decisions about each will be affected by progress in the other programs. The MHD program in particular has several major technology hurdles to overcome prior to commercial application using coal. While the MHD program appears to be adequately funded and structured, continuous assessment of progress in MHD development relative to the other technologies will be necessary to ensure that research expenditures yield the maximum benefit. By comparison, fuel-cell technology development deserves more support than it is currently receiving in ERDA. Both recent industrial progress in developing commercially feasible fuel-cell technology and the Congressional mandate in Public Law 93-577, Section 6(b) (3] (N) "to commercially demonstrate the use of fuel cells for central station electric power generation" indicate a need for more ERDA attention to fuel-cell technology,

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QUESTIONS

1. What is ERDA's projection of the MHD/combined cycle contribution to U.S. electrical energy production as a function of time?
2. What are the technical problems which must be solved before coal-fired open cycle MHD power plants can be considered for commercial operation?
3. What is ERDA's view of the relative merits of MHD, Rankine topping cycles, organic bottoming cycles, and fuel cells in terms of their potential for energy generation efficiencies and fuel savings as a function of time?
4. How does the ERDA program in fuel cells relate to the private industry commitment to this technology?
5. What will be achieved with the FY 76 budget of $500,000 for fuel cells? How would a greater expenditure on fuel-cell technology improve the program. ?

BACKGROUND

The MHD generator is a direct energy conversion device which transforms the kinetic energy of ions entrained in a high-speed gas flow into electrical energy by passage of the flow of gas and entrained ionized particles through a strong magnetic field. There are two basic types of MHD generators:

- Open-cycle, in which the working fluid is produced by the combustion of a fossil fuel and is passed once through the cycle.
- Closed-cycle, in which the working fluid is recirculated, the heat input being supplied via a suitable high temperature heat exchanger.

Since open-cycle systems utilize the combustion products as the working fluid of the cycle, they do not need any solid surface interposed between the heat source and the conversion device, and the temperature is fundamentally limited only by the heat source.

The primary utility of the concept lies in its potential use as a topping cycle for extending the upper temperature limit on conventional electrical generating systems, thus increasing the efficiency of energy conversion of the overall system from the presently achievable 38-40 percent up to 55-60 percent.

The MHD concept has been in development at the laboratory research level since the late 1950's.

Primary interest in the United States in MHD is based on the concept's projected ability to operate with direct coal combustion. The Soviet Union has a working demonstration system, but the Soviet U-25 facility is fired with natural gas.

There are presently three critical questions relating to the feasibility of MHD, the answers to which will determine whether the present research efforts should be continued. ERDA's program is pursuing the answers to those questions, which are described below.

The first problem area relates to the efficiency of enthalpy extraction, or the transfer of energy from the moving gas stream to the electrical circuit. The efficiency of this transfer is dependent on the orderly linear motion of the ionized gas through the magnetic field created by a superconducting magnet. What data are available indicate that efficiencies on open-cycle MHD achieved to date are in the vicinity of 8 percent, rather than the 20 percent which will be required for feasible application of the MHD concept. Over 20 percent enthalpy extraction has been achieved in closed-cycle MHD experiments. These percentages, however, were not obtained at the flow conditions and magnetic fields contemplated for commercial service. The open cycle enthalpy extraction was obtained in supersonic flow with a magnetic field of about two tesla. Commercial open-cycle generators are expected to operate in subsonic flow with magnetic field strengths of about six tesla. The closed cycle extraction was achieved at higher temperatures and lower magnetic field strength than are considered appropriate for commercial equipment.

A second major area of inquiry relates to the feasibility of preheating the combustor inlet air by exchange of heat from the gas exhausted from the MHD duct. The efficient and durable heat exchanger configuration required to accomplish this has not been demonstrated. (Such a high temperature heat exchanger, if successfully developed, would also be applicable to a wide range of advanced heat generation and fuel conversion processes).

The third critical area of inquiry relates to recovery of the ion "seed". The entire MHD process rests on the seeding of the combustion gases with a potassium salt, which both ionizes easily and preferentially combines with the sulfur in the coal to form potassium or cesium sulfate. The economic feasibility of the MHD concept requires virtually total recovery of the seed, which is then chemically processed for reinfection. The high recovery rate required has not yet been demonstrated in the slagging environment of a coal-burning MHD generator.

Assuming successful laboratory scale demonstration of these three critical processes, the further development of the MHD process to the commercial level will require many years. This fact is reflected in the schedules for the program in the ERDA documents.

Fluidized bed combustors and advanced gas turbines are described elsewhere in this chapter (Issues 9 and 10) and will not be further discussed here.

Fuel-cell technology holds great promise for electrical energy generation at efficiencies comparable to those claimed for the MHD/combined cycle technology. Industry has made significant contributions in fuel-cell R&D and has advanced the state of the art to the point where fuel cells using methane or natural gas are now competitive with standard steam generator systems in terms of efficiencies, There is need for continued research to further improve both the efficiency and the economics of fuel-cell systems. Fuel-cell technology can be a natural complement to low-Btu synthetic gas production from coal, and has further advantages in the potential for generation of electricity at the neighborhood or district level. The Congress, in Public Law 93-577, Section 6(b)(3)(N), directed the Administrator of ERDA to ". . . assign program elements and activities (including) research, development and demonstrations designed. . . (N) to commercially demonstrate the use of fuel cells for central station electric power generation." The amount budgeted for fuel cell R&D ($500,000) for FY 76 seems so little as to represent a token response to this mandate.

12. Interagency Coordination: Coal Cleanup

ISSUE

Coordination between ERDA and other agencies appears to be inadequate in activities relating to research and development of fossil energy. This is particularly evident in coal cleanup.

SUMMARY

The responsibility for many programs important to the successful development of increased fossil fuel supplies lies outside ERDA. While this division of responsibility acknowledges the scope and expertise of other agencies, ERDA, in its capacity as lead agency in formulating Federal R, D&D strategy, has a responsibility to participate in the design, development, and coordination of these outside activities and to evaluate their progress. This is necessary to ensure that no serious omissions or delays occur because of problems in non-ERDA programs on which ERDA programs are dependent either in their development or their implementation. Further, when policy decisions are made concerning alternative technologies, it is important that the criteria used in assessing the options do not vary among the decisionmaking agencies. In some cases, a redefinition of responsibilities may be desirable, A case in point is the problem of coal cleaning. Precombustion cleanup research is performed by the Bureau of Mines, during combustion cleanup by ERDA, and post combustion cleanup by EPA.

QUESTIONS

1. What mechanism is ERDA using to coordinate its programs with those of other agencies?
2. How are relative priorities established in program areas that involve several agencies?
3. Does ERDA believe the present level of R&D techniques matches their potential benefits?
4. Is the distribution of R&D responsibilities in fossil energy among the Federal agencies the most effective for achieving the national energy goals?

BACKGROUND

Important segments of the Nation's R, D&D programs in fossil energy are administered by agencies other than ERDA. For example, mining technology and ore beneficiation are located in the Bureau of Mines, fossil resource assessment in the Geological Survey, stack-gas cleanup in the Environmental Protection Agency but precombustion cleanup in the Bureau of Mines, and coal transportation in the Department of Transportation, This division of responsibility evolved from the previously existing agency charges and acknowledges the basic interests and expertise of the various agencies.

This separation of R&D programs among different agencies poses problems to successful implement at ion of overall energy strategy. ERDA, in its position as the agency directly responsible for formulating and implementing

Federal R, D&D policy, is charged by its legislative mandate with an oversight responsibility relative to energy programs which are not under its authority. It must participate in the design and development of important programs and provide the coordination to insure that no gaps or wasteful overlaps in programs occur; it must also continually monitor the progress of outside activities to avoid unnecessary delays. The size and effectiveness of programs devoted to energy-related problems by different agencies is likely to be quite variable, with no guarantee that the level of effort will match the needs. The criteria used to evaluate competing options can also be expected to vary depending on the agency. ERDA has a mission in reducing these problems.

One example of a division of responsibility important to the increased use of coal is the problem of coal cleaning. Precombustion cleanup research (e.g., magnetic desulfurization) is performed by Bureau of Mines, during combustion cleanup (e.g., fluidized bed combustion] by ERDA and postcombustion cleanup (e.g., stackgas scrubbing) by EPA. Are the relative levels of effort of these various research programs adequate in proportion to their potential contributions to the different technologies for the use of coal in utilities and industry? An answer to this question cannot be obtained from the ERDA documents. The present distribution of research programs must be carefully examined to determine whether it provides the best approach to solving environmental problems associated with coal combustion. Some reassignment of responsibilities may become desirable.

13. Environmental, Social, and Political Impacts of Mining

ISSUE

Even if mining technology is adequate to support an expanded use of coal and oil shale in the United States, there are potential obstacles associated with environmental, social, and political impacts of a massive increase in mining.

SUMMARY

A major increase in electricity y generation from the direct combustion of coal or the conversion of coal to synthetic gas and liquid fuels at a commercial scale will require a significant expansion of coal extraction, For example, a 250 million cubic feet per day plant for producing pipeline gas from coal will require a coal mine as large as any presently operating in the United States. The plant will consume more coal than is now mined in Utah. An activity of this scope will almost certainly encounter resistance from groups in society that are especially concerned about environmental quality; these groups may have considerable influence at State and local levels. If these concerns are not to become a serious constraint to the use of improved fossil fuel technologies, ERDA must be sure that necessary programs are established to reduce uncertainties about environmental and social impacts and to mitigate serious negative impacts,

QUESTIONS

1, Are the research activities of Federal agencies, other than ERDA, sufficient to avoid future environmental and social constraints on the application of improved fossil fuel technologies?

2 What are the options—and the pros and cons—for accommodating the concerns of States about potential negative environmental and social impacts of an expansion of coal- and oil-shale mining?

30 How large a community must be established to build and operate a commercial-sized synthetic fuel plant and its associated mining activities?

BACKGROUND

Coal, as our largest domestic fossil energy source, and oil shale, as a sizable resource for liquid fuels, are certain to increase in importance in the national energy picture; for example, the current goal is to double coal production to 1.2 billion tons a year by 1985. Along with the technological challenge of mining at such a scale, there will be major concerns about mineland reclamation, waste disposal, protection against water pollution, “boom and bust” urban growth, water consumption, and other environmental and social impacts of the mining activities.

Opinions differ as to the seriousness of these problems. Some believe that they are major impediments, likely to block a rapid increase in coal- and oil-shale utilization. Others believe that they are not serious problems and that the opposing view is misinformed. But representatives of both points of view agree that a better base of information about these impacts would help to reduce delays in applying improved fossil fuel technologies. Thus broad and detailed studies are in order on environmental problems associated with coal and oil shale mining, such as waste disposal, reclamation and revegetation, watershed protection, and water supply and conservation, to increase as rapidly as possible the range of options for mitigating negative impacts. Also, improved understanding of the social and economic impacts of locating new, large communities in sparsely populated regions will assist in planning for these communities and satisfying the legitimate concerns of local residents,

A special concern of many coal or oil-shale rich States is that they will have to bear the burden of negative impacts for the sake of meeting the energy needs of consumers in unaffected States. This introduces important questions in Federal-State relations. In some respects, the increased use of coal and oil shale will be a process of political accommodation, and ERDA can accelerate the process by such activities as the preparation of regional programmatic impact statements and the collection of data to buttress them,

The proposed ERDA budget does not appear to include sufficient funds for the kind of effort that is needed,

14. Manpower

ISSUE

ERDA's program for massive expansion of the use of coal will require far more trained personnel at various levels than can naturally be expected to enter those sectors of the labor market.

SUMMARY

ERDA estimates of increased coal production will require a significant increase in the number of underground coal miners, including first-line supervisory personnel and coal mining engineers. The fluctuating production levels of the coal mining industry over the last 25 years has resulted in a current work force composed principally of miners over 50 or under 30 years of age. Simultaneously, advanced mining techniques and machinery impose a requirement for more education and special training. Coal research and mining engineering programs at the university level are few and thinly staffed. Significantly more faculty are needed to expand and multiply these programs. The development of gasification and liquefaction plants will also increase demand for both university-trained professionals and for subprofessionals with special skills. Failure to support the development of the necessary manpower pool in these and other areas requiring critical skills could result in failure to achieve the goals which ERDA has set, even if the technology and other required inputs are available.

QUESTIONS

1. What special ski lls are critical to the success of the proposed fossil fuel programs, and how many ‘trained personnel will be needed?
2. What information is available concerning the ability of existing professional and trade educational facilities to provide the necessary trained personnel?
3. What impact will o her energy programs have on manpower available for the fossil fuel industries?
4. What level of ERDA support for educational programs is planned to provide the necessary manpower, and over what period of time?

BACKGROUND

The future in fossil fuel production and consumption envisioned in the ERDA program consists of a continuing decline in the supply of petroleum and natural gas from primary sources, with the difference between supply and demand being replaced primarily by coal, either in direct use or via conversion to liquid and gaseous synthetic fuels. The projected massive increase in coal extraction and processing will require a comparably massive injection of newly trained manpower into industries which either have languished for decades or are now in their infancy.

The manpower supply situation for the required increase in coal production may become severe. There are certain special skills required by underground miners which can only be gained by experience. The recession in the industry that reduced production during the post-war years curtailed recruitment, so that the average age of skilled miners is now in the upper 40's. Young people are being recruited in increasing numbers, but there is a missing generation and the continuity has been broken. The father-to-son tradition and local community spirit have largely disappeared, Moreover, there has been a significant increase in the technical training required to operate and maintain the sophisticated machinery that is now in use. Supervisory personnel who would normally be drawn from the middle generation are not available, and intensive education and training are necessary to assure a stable skilled work force.

Strip and auger mines have fewer problems in recruiting personnel, provided job, wage, and living conditions are comparable, since they can draw on general construction skills. Strip mining is capital intensive; a large dragline or shovel may cost more than $15 million fully installed, requiring full utilization and operation by highly trained personnel.

There was a significant increase in the mine work force in 1970 following the enactment of the Mine Enforcement and Safety Act; employment jumped from 124,000 to 140,000 workers. During 1970-74, manpower increased by an additional 10,000 employees to 150,000.

Because of a decline in underground mining productivity, overall industry productivity declined from 19.9 tons per man in 1969 to 17.3 tons per man in 1974. Strip mine productivity remained about the same at 36 tons per man, and auger mining increased from 40 to 45 tons per man. The effects and the measures required by the 1969 Mine Health and Safety Act have now been absorbed by mine operators and may not cause any major additional impact on future mining manpower or costs, although their effects will escalate steadily in step with other mining costs.

Projections of production, manpower, and productivity for 1985 are:

Production	1.0 to 1.2 billion tons
Work Force:	
Underground mines	160,000 persons
Strip and Auger Mines	75,000 persons
Total Estimated	235,000 persons
Productivity Per Employee Shift:	
Underground Mines	13 to 15 tons
Strip Mines	40 to 45 tons

In general, the following developments can be anticipated:

- The labor force will be composed of highly skilled technicians, electronic and hydraulic experts able to operate and maintain sophisticated and costly equipment.
- Underground and strip mine workers will be more highly skilled, younger, and better paid.
- There will be an increasing demand for mining engineers and other engineering skills to maximize system performance.
- There will be increased need to upgrade the educational level of the work force through trade schools and adult education facilities.

The requirement for university-trained personnel raises an additional set of problems. There are at present only three substantial university coal research programs and only 5 schools which teach coal preparation technology. The number of students in these programs is quite small, The opening of new college and university programs and the expansion of existing departments is likely to distribute more sparsely an already small faculty base unless special attention is paid to this area. The support of university training programs via R&D contracts does not appear to be an adequate response to the problem for two reasons. First, universities that are under pressure to produce competitively in R&D programs often compete for professional manpower and neglect their educational role. Second, universities may be unwilling to undertake long-term educational programs in support of R&D because of past experience in which abrupt cancellations of support left them with unsupported educational programs. Direct support through fellowship and traineeship programs at both graduate and undergraduate levels will probably be required in the educational areas where a future shortfall of personnel is identified.

15. Transportation Systems

ISSUE

The application of fossil fuel technology research will require improved transportation systems in the United States.

SUMMARY

A shift from the use of crude oil and natural gas, imported or domestic, to the use of coal and synthetic fuel products from coal will make heavy demands on existing transportation systems. The rail network, which moves most of the Nation's coal, will be especially affected. In order to avoid major constraints on the application of improved fossil fuel. technologies, ERDA needs to anticipate the commodity movements that may be required and to assure that necessary additions to or changes in present transportation systems are brought about.

QUESTIONS

1, What are the interregional transportation requirements of ERDA's scenarios in volume 1, and how do they compare with the present capacities of transportation networks?

2. In ERDA's opinion, what are the prospects for an increased use of coal slurry pipelines?

3. To what extent are the needed changes in transportation capabilities a problem of Federal regulatory policy rather than a problem of technology development?

BACKGROUND

Whenever an energy product is produced at a location other than where it is to be consumed, it must be moved, We are well aware of the importance of pipelines for oil and natural gas in the United States today, and we are increasingly aware of the need to move large quantities of coal from mines to the locations of electrical generation plants, industrial users, and other consumers.

As a larger portion of the energy in the United States is made available from domestic resources other than oil and natural gas, the demands on our transportation systems will grow rapidly, and the present systems will certainly prove inadequate. For example, 44 percent of the electricity in the United States in 1972 was generated by burning coal, and 69 percent of the coal was moved by rail, If new technologies for the direct combustion of coal allow the 44 percent to be increased to 70 percent, replacing most of the portion now fueled by oil and natural gas (37 percent in 1972), the impact on the Nation's rail system will be massive: congested rail lines, a shortage of coal cars, pressure for revised tariff structures, etc. This will be especially true if much of the increase is based on western coal, because the distances from mine to market will usually be greater and the rail network in the West is much less dense, adding to the chance of bottlenecks and posing a problem of national security.

Other transportation systems may be problematic as well. Demands for barge transportation will increase, with the same dangers of congestion, equipment shortages, and pressures for price increases. Slurry pipelines, an alternative to the rail or barge transport of coal, presently require negotiations for easements with each State to be traversed, and they are significant users of water. The production of synthetic oil and gas will in many cases require either new pipelines or the reversal of directions of flow in existing ones. And there are numerous questions of fuel or energy storage configurations and regulatory responsibility. For example, coal slurry pipelines are the responsibility of ERDA; natural gas pipelines and electrical transmission are regulated by the Federal Power Commission; and rail transportation is overseen by the Department of Transportation and the Interstate Commerce Commission.

If coal utilization and conversion technologies are to be used to meet national energy needs, ERDA must assure that transportation systems will be capable of meeting the new demands on them. This calls for a wide-range study of the relative locations of resources and users, the capacities of transport networks that link them, and strategies for mitigating anticipated problems. The effect of tariff structures in transportation on the development and use of fossil fuels also needs to be studied.

16. Water Availability

ISSUE

ERDA has not established a systems-oriented study of water availability related to its energy program.

SUMMARY

ERDA has defined programs for extensive development of U.S. coal resources, for oil shale, and for increased electrification as part of its overall strategy for supply of energy in the United States, These programs all imply a greatly increased demand for water, in terms of both withdrawal and consumption. When these programs are viewed in the context of the total ERDA program, including nuclear and geothermal energy programs, it is apparent that the availability of water to supply commercial level energy production activities is uncertain, especially in the fossil fuel area. A large percentage of the fossil fuel development programs relate to the use of low-grade coal, generation of low-Btu gas, processing of oil shale and other activities which involve fuel sources or product streams which are not economically transportable. These activities may be located primarily in the resource-rich but water-short Northern Great Plains and Colorado River Basins. There is no evidence in the ERDA Plan of any coordinated water-resource planning activity to facilitate the implementation of the technologies for fossil energy production which ERDA has defined as critical to future energy supply.

QUESTIONS

1. Which division of ERDA has primary responsibility for maintaining an overview of water availability for ERDA's projected fossil fuel supply strategy?
2. Which division of ERDA has primary responsibility for maintaining an overview of water availability for ERDA's total energy supply strategy?
3, What is the nature and extent of ERDA's cooperative activities with other Federal and State agencies in the areas of water availability, allocation of water rights, and regional water quality maintenance?

BACKGROUND

There is widespread concern in the Western States about the water consumption requirements of coal gasification and liquefaction, oil shale liquefaction, and electrical power generation from coal. Every comprehensive energy supply plan for the United States calls for siting new facilites in the Northern Great Plains and the Upper Colorado River Basin, and these are areas where water is considered a precious commodity, a resource to be allocated with care, Present water consumption in these areas is well short of average supply levels, and representatives of the energy industry believe that adequate water is available for a commercial fossil fuel-based energy industry. But as long as there is considerable uncertainty in the minds of citizens of States like Montana and Colorado, the water question can be a focus for political resistance to new commercial facilities. Consequently, it is vital that water resources for western fossil fuel development be assessed carefully, clearly, and publicly—and compared with water consumption requirements for commercial developments that would be the result of ERDA-supported R&D. An adequate assessment wil 1 have to include water rights law, the economics of water resource development and use, seasonal and annual variations in surface water availability, interstate compacts for the downstream delivery of water, preferential treatment for (and the definition of) "beneficial" uses of water, and groundwater resources available for use without long-term depletion of underground water reservoirs.

Chapter III

Nuclear Task Group Analysis

A. NUCLEAR TASK GROUP

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C. INTRODUCTION

Under the Atomic Energy Commission, nuclear power enjoyed substantial funding compared to that available for alternative energy sources. Though the existence of ERDA is expected to bring about a more appropriate balance, the need for nuclear power has never been greater, and many problems remain. Research and development to find solutions to these problems may require expansions in what is still by far the biggest part of ERDA's budget. The major issues in fission, fusion, and supporting technologies are discussed here. More detailed discussions of the nuclear program elements are given in the issue papers,

1. Converter Reactors

Light-Water Reactors. Light-water reactors (LWR's) now supply about 8 percent of the national electric energy needs (or 2 percent of all energy), and they will almost certainly dominate the nuclear industry for the next 2 decades. The reactor technology is well in hand, but many problems still exist, as evidenced by rapidly increasing costs and long leadtimes. These, in conjunction with the capital squeeze and power demand reduction, have caused the recent plant deferrals and cancellations. Nevertheless, the ERDA-48 Scenario 111 goal of 225 reactors by 1985 could be attainable if financing, licensing and manpower constraints are reduced, since that number of reactors have already been built or ordered. The projected plant startup rate in the remainder of the century, although twice that of the 1975-85 decade, still averages only to the number of plants (35) that were ordered in 1973. The primary obstacles to achieving either goal appear to be financial and institutional, not technological.

The cost and leadtime problems could be substantially alleviated if design, construction, and licensing techniques were improved. ERDA's new program addresses these problems, but the resources devoted to plant standardization seem insufficient to fully realize its potential to speed construction and cut costs. Issue Paper 1 discusses these problems and a possible standardization program.

While the reliability of large LWR's has been equivalent to comparable-sized fossil plants, it has been less than expected, An increase in nuclear plant availability would have a substantial effect on oil consumption, since utilities often must replace the missing base load capacity with oil-burning units. Each large LWR generates heat at a rate equivalent to more than 40,000 barrels of oil per day. The ERDA program addresses the major causes of unreliability; Issue Paper 2 discusses reliability and advanced safety and efficiency concepts.

The floating nuclear plant (FNP), which would be factory built on a barge and floated into its permanent location, offers the possibility of speeding construction and cutting costs. Utilities have been reluctant to order these plants, however, because of the general slowdown in new plant orders and because of doubts as to the licensable nature and ultimate performance of the plants. As a result, the only supplier of FNP's is now in a precarious financial condition. A proposed ERDA program to stimulate introduction of FNP's is discussed in Issue Paper 3.

High-Temperature Gas Reactor. The only American competitor to the present LWR which is near commercialization is the helium cooled high-temperature gas reactor (HTGR). It offers a higher efficiency than the LWR, equivalent to the best fossil units; a possibly more easily managed safeguards problem; potential use as an industrial process heat source because of its higher operating temperature; and freedom from midterm fuel resource worries. It is, however, more expensive than the LWR, and utilities have less confidence in its reliability because of very limited and less than reassuring operating experience with the Fort St. Vrain demonstration plant, As a result of these factors, about half of the HTGR orders have been canceled, and the manufacturer may have difficulty surviving. The HTGR concept seems to be worth developing as a viable option, but the present ERDA program may be insufficient to accomplish this, ERDA may soon have to decide whether to provide greater support or let the concept die, Issue Paper 4 discusses the HTGR potential and program.

Other Converter Reactors. At present, there seems to be little advantage to foreign converter reactors. This situation could change in the next few years if the Canadian deuterium-moderated reactor (CANDU) continues to show superior capacity factors. This reactor uses natural uranium, thus avoiding the expensive enrichment process, and consumes slightly less fuel than the LWR over its lifetime. Its lower thermal efficiency and its need for large quantities of heavy water, which require large amounts of energy to produce, tend to offset these advantages. In addition, the licensability of the CANDU reactor under existing Nuclear Regulatory Commission (NRC) regulations appears doubtful. Importation of the reactors appears undesirable for reasons of energy independence and balance of payment considerations. Alternatively, if these reactors were to be produced domestically under Canadian license, U.S. industry would have to make a costly conversion to the manufacture and support of a very different technology which probably will be superseded in the near future, The advanced CANDU is under development and shows promise of greatly extending resources and producing power more cheaply than the present design. ERDA should follow this development closely.

2. Breeder Reactors

Liquid Metal Fast Breeder Reactor. The liquid metal fast breeder (LMFBR) is the most technologically advanced of the breeder technologies both here and abroad. It is much closer to technological and economic success than the other "inexhaustible" long-term energy sources and has the potential to produce vast quantities of power early in the next century at a competitive price. It could do this in a manner that is more acceptable environmentally than any present technology. Nevertheless, it is the most controversial item in the ERDA program.

Controversy centers around the cost of the R&D program, especially relative to the funding of alternative energy sources; the economics of the LMFBR when fully developed; the quality of the design; the increased safeguards problem that will result from the large quantities susceptibility to sabotage. Issue Paper 5 discusses these issues and the program goals and problems.

The ERDA expectation of 80 commercial LMFBR units by the year 2000 is optimistic in view of the recent delay in the Clinch River demonstration plant, This is probably not critical, however, because many of these projected units could be replaced by converter reactors.

Gas-Cooled Fast Reactor. The gas-cooled fast reactor (GCFR) is a possible successor or supplement to the LMFBR, It has a higher breeding ratio and thermal efficiency and may entail more easily managed problems of safety and safeguards than the LMFBR. Technological development of the GCFR is less well advanced, however, and substantial development work is needed in such areas as component development and fuel-cycle analysis. Issue Paper 4 discusses the GCFR with the HTGR, since the two are intimately related technologically.

Light-Water Breeder Reactor. The light-water breeder reactor (LWBR) is designed to utilize much of the present pressurized water reactor (PWR) technology, Ideally, the reactor itself would fit into a present-generation PWR vessel, with some derating of thermal output, and produce as much fuel as it burns. Thus, temporary freedom from fuel resource limitations might be achieved with a small expenditure for research and development and a relatively low capital cost increment. Too few details have been released for a realistic assessment to be made. Little is now known of the fuel-cycle cost or licensing problems, and utilities have shown little interest in the LWBR concept. Issue Paper 6 covers the project and its potential.

Molten Salt Breeder Reactor. The molten salt breeder reactor (MSBR) is a totally different breeder design that has been funded for many years at a very low level, If successful, it would simplify the safety and safeguards problems because of its continuous fuel reprocessing and use of thorium fuel. The fuel breeding ratio is much better than that of the LWBR, but is unimpressive compared to the LMFBR and GCFR. The lower fuel inventory should mean that lifetime uranium requirements are no greater than for the LMFBR. Despite the many unique technical problems that remain to be solved, the MSBR offers sufficiently significant advantages to be funded at a higher level to allow a realistic determination of its potential. Issue Paper 7 discusses the relative merits and problems of the MSBR.

3. Supporting Technology

Environment and Health (Issue Papers 8 and 9). The nuclear environmental hazards during normal operations are well understood relative to the hazards associated with coal-fired powerplants and, on balance, appear relatively small. Much work, however, is still needed, especially on the question of plutonium toxicity.

Waste Disposal (Issue Paper 10). Several waste disposal options that appear technologically feasible are under consideration. Disposal in carefully selected salt beds or areas in the ocean floor are both possible. Public acceptance is a less tractable problem. A strong effort is required to allay public fears, but it must result in a technically well supported choice that will not have to be revoked, as was the plan to use the Lyons, Kansas, salt bed. Reprocessing of spent fuel with actinide removal can greatly ease the waste disposal problem by reducing the time from 200,000 years to about 500 years that wastes present a danger (and must be isolated). The relatively small volume of actinides could be stored separately in a very safe location or put back into a reactor to be burned up. With suitable dilution, the radioactivity diminishes to about the level of uranium ore in 500 years even without actinide removal. If reprocessing does not become widespread, ERDA should have ready a plan for retrievable storage of fuel elements.

Safeguards (Issue Papers 11 and 12). Nuclear material diversion by clandestine groups to construct weapons is a difficult problem which involves abnormal human behavior and potentially devastating consequences. It seems probable, however, that technical solutions can be devised to keep the risk of such diversions at acceptably low levels. The cost is not expected to be prohibitive, but a continuing effort will be required to make the system perform according to design, A promising possibility is to locate reactors and their associated fuel reprocessing plants and fuel fabrication plants together in a nuclear park. This would eliminate the transportation links and thus reduce the possibility of diversion. Siting, environmental, and other problems, however, may be greater than for present methods.

Resource Base (Issue Paper 13). All estimates of the Nat ion’s ultimate uranium resources are still highly uncertain. Critics have claimed that the ERDA estimate is either too high and therefore exaggerates the potential importance of nuclear power, or that it is too low and overemphasizes the need for the breeder. Utilities already are worried about ensuring the supply of fuel for the lifetime of new reactors, perhaps in part because the price of uranium has risen sharply recently, Since very important decisions, such as the breeder timetable, depend on the estimates of U.S. uranium resources, it is vital that they be substantially more accurate, ERDA should consider expediting its National Uranium Resource Evaluation Program.

Enrichment (Issue Paper 14). The present and planned capacity of ERDA gaseous diffusion enrichment facilities is fully subscribed, and new capacity will be required by about 1985. The Government anticipates that private industry will provide the needed expansion, but it is estimated that industry would require 9 or 10 years to learn the technology and get their first plant operating. If industry and Congress do not take positive action very soon, ERDA itself must consider building another enrichment plant or increasing the capacity of existing plants. The centrifuge separation technique shows great promise, but it is not as far advanced as gaseous diffusion; nevertheless, the succeeding generation of commercial enrichment plants may well be a centrifuge type. Centrifuge technology and, to an even greater extent, the laser separation technique, have potential for illicit use because of their adaptability to small-scale production.

Fuel Recycle (Issue Paper 15). The NRC has tentatively delayed plutonium recycle until the safeguards issue is adequately addressed. Plutonium recycle greatly increases the risk of diversion of weapons-grade material or accidental release of a highly toxic substance, In addition, the economics are now only marginally attractive. Industry, however, expects to proceed when possible as reprocessing should somewhat improve the economics of the fuel cycle, facilitate waste storage, and extend the uranium resources. Experts are divided on this issue. Some experts want to aid industry as ERDA proposes to do; others feel the hidden social costs will be greater than any possible societal benefit. While the lack of recycle capability will not become critical until the breeder is commercialized, the issue should be resolved soon because LMBFR economy rests on plutonium recycle, and a significant energy source is being neglected.

Public Acceptance (Issue Paper 16). There is a great deal of opposition to the siting of almost any nuclear plant. While some objections are irrational, real concerns such as the emergency core cooling system performance, safeguards, and waste disposal have not yet been fully resolved, ERDA should discuss these problems publicly and candidly while dispelling public misconceptions, such as the possibility of nuclear explosions in powerplants.

4. Fusion (Issue Papers 17 and 18)

There is a consensus that if nuclear fusion can be successfully harnessed to give economic power, it would be a very attractive means of supplying much of the Nation's electrical energy needs by the next century, The abundance of cheap fuel, the low level of radioactive waste products, and nuclear explosive materials are among the advantages that would accrue from successful fusion power, The required research and development deserves favorable funding within the Nation's long-term energy program. However, the scientific demonstration of fusion feasibility—that is, that the required temperatures and containment for thermonuclear burn can be achieved—has yet to be shown.

Substantial advances have been made in recent devices (tokamaks and laser experiments), but there is no certainty that these experiments can be scaled up in size and power to give the required conditions, The R&D will necessarily take many years, will be very expensive, and as yet carries no guarantee of success. Nevertheless, the potential is so great that it should be vigorously pursued.

There is concern, however, as to whether ERDA has narrowed the focus of its fusion program too much by its heavy concentration on the tokamak concept. The ERDA Plan calls for scaling up the tokamak device to machines in which scientific feasibility (energy "breakeven") can be achieved. Although this scaling up appears to be a necessary process to achieve success in the fusion program, the cost and complexity of these next generation machines raises questions as to whether options on other promising fusion concepts can be kept open in case the tokamak concept is not successful. If continued assessment of program directions is not carefully maintained, there is danger of premature abandonment of other fusion concepts.

The economic harnessing of fusion power will require several new technologies, including new materials for the reactor walls, economic storage of large amounts of energy, large superconducting magnets, and the safe handling of tritium, Since developing these new technologies will take many years, adequate R&D programs should be started now to avoid possible delays in the overall program, There is evidence that the ERDA Plan has done this. Continued assessment is a necessity to ensure a balanced effort.

D. NUCLEAR ISSUE PAPERS

1. Standardization

ISSUE

The present procedure for the design, construction, and licensing of a nuclear powerplant is time-consuming, inefficient, and costly. An ERDA-supported standardization program could allieviate these difficulties.

SUMMARY

At present, virtually every nuclear powerplant is custom designed and built by a combination of suppliers. This procedure leads to very complex interfaces between the various suppliers, the utility, and the NRC. The incomplete status of the design at the time the construction permit is issued (conditioned upon the resolution of incomplete design features) and the changing regulatory requirements result in many design changes, imposition of retrofitted systems, delays, and cost increases. Standardization is a potential solution that is not feasible in the present environment of fragmented responsibility and rapidly changing regulatory requirements.

ERDA could support the development of a standardized design of a complete nuclear powerplant for which the NRC would issue a "license to manufacture." Participation by all concerned parties would ensure a high-quality design. The licensing review of the utility's application would be limited to site-related issues and would require only a small fraction of the present licensing time and cost.

QUESTIONS

1. Is ERDA willing to consider participation in a program to promote standardized nuclear powerplant design and construction'?
2. Are there significant antitrust issues involved in terms of specifying brands of pumps, valves, control systems, instruments, etc, ?
3. What are the advantages of standardization over present procedures if the latter were implemented more expeditiously?

BACKGROUND

When a utility decides to build a nuclear powerplant, it usually selects a nuclear steam system supply (NSSS) vendor, an architect/engineer [A/E], and a constructor, The NSSS designs are fairly well standardized by each of the four LWR vendors. The balance of the plant, which costs considerably more than the NSSS, is designed by the A/E. The A/E generally starts with a previous design and revises it depending on NRC requirements, utility preferences, and site requirements. The constructor (often the A/E) then builds the plant according to the NSSS vendor and A/E drawings. This is basically the same procedure historically followed for fossil plants. It results in a custom-designed and built plant, which then must be individually reviewed by NRC,

This fragmented approach leads to a division of responsibility and contributes to uncoordinated overall systems design. In addition, there are so many combinations of NSSS vendors and A/E's that the A/E may find all his projects quite dissimilar. If the A/E does have a prior design to follow, he may copy previous mistakes or otherwise fail to cut costs as much as possible because of the pressure of the schedule.

Standardization is a potential solution to these problems, but it has not happened yet for a number of reasons. The multiplicity of A/E's and NSSS vendors could make each combination a separate design. Technological advances leave previous designs outdated, but this process seems to be slowing, The largest roadblock of all, however; has been the NRC and its changing regulatory requirements.

At the time the utility submits an application to NRC for review, the detailed final design of the nuclear plant is generally no more than 10 percent complete, and it is usually less than 50 percent complete at the time that the construction permit is issued, This lack of a completed design leaves the utility extremely vulnerable to NRC-imposed design changes, which all too often involve ripping out a portion of the plant already constructed and replacing it at a significant cost and delay in the schedule.

Some of these changes are the result of oversight or the analysis of previously unsuspected but creditable ramifications of accidents, These changes should be incorporated into the designs if they involve a significant risk to public health and safety. Many changes, however, are attributed simply to new regulatory guides and changes in requirements that are applied retroactively,

Two years ago, the AEC announced a policy of supporting standardization. There have been a number of recent attempts to improve the situation—the SNUPPS group of plants (five virtually identical plants ordered by four utilities), the Duke Power Company "six pack" and the floating nuclear plant being put forth by Offshore Power Systems (OPS), Indeed, the NRC regulations were actually modified to provide a "license to manufacture" to OPS who will manufacture the FNP in a factory and then deliver it via water to the utility's prepared site, None of these concepts, however, has enjoyed the full anticipated benefits of standardization, particularly in regard to the licensing process,

One possible role for ERDA would be to support the complete design of a land-based nuclear powerplant through the whole licensing process, including the issuance of a "license to manufacture," and then to offer it to all interested utilities for a prorated fee, based on the projected number of users. If the design is carried out with the input from a number of utilities who are interested in proceeding with the project, it should represent an acceptable design, Indeed, the possibility y of saving up to 3 years in licensing time (especially if a procedure for preapproving sites is also implemented) would be so attractive to a utility that prudence might dictate that it accept such an approved standardized powerplant.

The principal advantage of this arrangement is that the design, once approved for a period of time, would be subjected only to those changes which have a significant impact upon the health and safety of the public. As a result, the financial exposure of the utility would be minimized, since it has only to secure the approval of the site via the environmental and site suitability hearings.

2. Performance and Reliability

ISSUE

Problems relating to the performance and reliability of light-water reactors have received insufficient attention since the AEC ceased nonsafety light-water reactor R&D.

SUMMARY

Until the late 1960's, substantial governmental research work was carried out on light-water-cooled nuclear power reactors. At that time, the AEC decided that LWR's had reached commercial status area. Following that decision, a number of problems developed. First, the nuclear industry has been slow to see the need for and to initiate extensive R&D efforts of its own. Second, increases in reactor power levels greater than those warranted by existing technology resulted in component performance and reliability problems. Third, continuous AEC tightening of safety-related design criteria and operating restrictions over the past 6 to 8 years has resulted in economic penalties and reduction of plant operating flexibility. With respect to the first two problems, it is noted with approval that ERDA is planning to renew governmental support of R&D aimed at improving LWR performance and reliability. The third problem would seem to be NRC's responsibility. However, it is questionable whether NRC has adequate incentive for doing research to optimize the balance between costs and safety. Furthermore, it has little incentive to develop improved safety concepts or systems so long as it considers its primary responsibilities to the review of proposed systems for adequacy. The ERDA LWR safety program can serve both to control the costs of safety systems and reduce the unknown factors in safety-related areas, thereby possibly increasing safety margins and reducing public fear.

QUESTIONS

1. What is the proposed scope and level of effort by ERDA on LWR component performance and reliability?

z. What will be the relationship between the ERDA and NRC programs in LWR safety research?

3. Who will ultimately decide the balance between economies and safety in LWR's?

BACKGROUND

Over the past 20 years, substantial Government research and development has been carried out on light-water-cooled nuclear power reactors, Most of this work ceased in the late *1960's* as a result of an AEC decision that light-water reactors had reached commercial status and that, except for safety research needed to support the regulatory process, the nuclear industry should assume the responsibility for further research efforts. Subsequent to the AEC decision a number of difficulties have developed.

- The industry has been slow to initiate extensive research efforts. For example, significant research efforts by the Electric Power Research Institute (EPRI), supported by the electric utility industry, have only begun within the past 2 years.
- Over the past 6 to 8 years, there has been a large increase in the operating power levels of light-water-cooled nuclear power reactors. Although efforts are made to accomplish this power increase in a way which makes maximum use of previously developed technology, a number of performance and reliability problems have resulted that require substantial R&D in order to be satisfactorily resolved. Such problems include fuel densification, Zircaloy-clad hydriding, stearn-generator tube failures, and premature component failure, The new large fossil plants exhibit somewhat analogous behavior, but downtime on nuclear plants is more costly because of their higher capital costs, which must be carried regardless of the output. When the baseload units are inoperative, utilities must make up the missing power by using higher priced fossil fuels. This generally means oil, because oil-fired units are most economical for peak loads or emergencies.
- Safety-related design criteria and operating restriction imposed by the AEC (NRC] have tightened continuously over the past 6 to 8 years. This trend, exemplified most recently by the decision to adopt new criteria for evaluation of light-water reactor emergency core cooling systems, has led to a situation where a few reactors are operating at power levels below the power level for which they were designed and/or are severely limited in operating flexibility. In addition, new fuel designs are being pushed in a direction which significantly reduces economic performance. That these trends and effects are in the direction of increased safety and that reactor safety is important cannot be questioned. Nevertheless, there is a wide difference of opinion among qualified engineers and scientists as to whether this increased level of safety is either significant or needed and therefore worth the cost,

With respect to the first two of the above problems, it seems evident that if light-water reactors are to continue to be developed and utilized effectively, additional R&D will be required in individual component and system performance and reliability, Moreover, if this is to be done quickly, a significant increase in the level and scope of Government support will be needed. It appears that high payoff will result from increasing Government support of R&D relating to these areas of reactor technology. In addition, more advanced concepts to improve performance could be investigated. These might include the production of superheated steam, either in the core of boiling water reactors or in advanced steam generators of pressurized water reactors.

At first glance, it would appear that resolution of the third problem area is the responsibility of NRC and/or the nuclear industry, and, indeed, a number of research programs funded by both industry and NRC are presently underway. However, in considering the possible eventual result of such programs, it is important to note that, over the 10 years since the AEC began limiting its R&D efforts to safety R&D in support of its regulatory role, there have been virtually no instances where safety regulations have become less rather than more restrictive, The problem is that NRC does not have an incentive to do research needed to develop and justify regulations which provide adequate assurance of safety at a minimum cost. Also, it has no incentive to develop improved safety concepts or systems so long as it considers its role to be primarily the review of proposed systems for adequacy. ERDA, on the other hand, having a responsibility for effective development and use of nuclear power, does have such an incentive, It seems likely that industrial efforts will need to be supported by the Government if they are to be effective in the near future. Therefore, it is recommended that ERDA increase its efforts in areas relating to LWR safety,

3. Floating Nuclear Powerplants

ISSUE

Floating nuclear powerplants (FNP's) offer potential improvements in LWR licensing and construction, but implementation is in doubt.

SUMMARY

FNP's are commercially available, although none have yet been built. After several years of design and sales effort, only four units have been sold to one utility, and all four of these units were recently delayed from the 1979-86 period to the 1984-90 time period. As a result, the supplier is in financial difficulty. If this company fails, the FNP, which represents a major step forward in standardization, will be eliminated for the foreseeable future as an option in meeting the Nation's energy generation needs.

The FNP is to be built in a factory setting favorable to rapid, high-quality construction and controlled costs. The plant design is to be approved by NRC prior to the issuance of a "license to manufacture"; hence, a utility has only to license the site. Indeed, the concurrent construction of the plant and the licensing and preparation of the site significantly reduces the time to install FNP's.

The present reservations about FNP's among utilities concern the licensability of the plant and site, and the performance of the plant upon completion. ERDA should consider aiding utilities in the licensing process and guaranteeing operating performance if the reactor vessel melt-through problem can be satisfactorily resolved.

QUESTIONS

1. Are the licensing questions of FNP's so serious that a utility committed to nuclear power would not accept the risk of delays and additional costs to resolve the issues involved?

2, Are there any reasons that a FNP would not be expected to reach rated power or be restricted to less than rated power by NRC?

BACKGROUND

An innovative concept which has been brought to the point of commercialization is the FNP, in which standardized plants are assembled on a regular schedule in a factory. Each plant would be installed on a barge and towed to its site, which might be located offshore or in a more protected site in a bay or lake. The FNP concept offers significant financial, schedule, and quality control advantages, but it does involve some uncertainty in licensable nature and performance. ERDA could assist in resolving these questions,

Siting of FNP's is a unique problem in that a specially designed protective barrier around the plant will probably be required, even shore-based units, will require some protection. The loss of coolant accident protection systems requires special attention since, according to the Rasmussen Report (WASH 1400), the chance of an accident leading to a reactor vessel meltthrough could be as high as 1 in 100,000 reactor-years. Some of these in turn could lead eventually to a containment floor burnthrough. At a landbased unit, extensive release of radioactive material might still be avoided if the molten core cooled sufficiently to solidify without coming into contact with ground water. At an FNP, however, after burning through the containment floor, the molten core would drop into the ocean or lake where the plant is located. The special problems associated with fission products in the water present a unique type of licensing issue. Resolving such uniquely different licensing questions is a task ERDA could undertake with NRC.

Certain other technological questions still are being examined by NRC. Some of these issues—such as turbine/generator alignment on a floating barge—could result in a restriction of the plant power level or operational difficulties, The only existing plant using a containment ice condenser pressure suppression system similar to that planned for FNP's is presently operating at less than rated power due to licensing restrictions,

ERDA could assist the utilities by undertaking R&D to resolve any problems that impose power restrictions. Since the first few utilities to install FNP's will bear the brunt of any technological problems, it may be advisable for ERDA to guarantee the performance of the first plants.

4. Helium-Cooled Reactors—Converters and Breeders

ISSUE

Helium-cooled reactors have some potential advantages not offered by water- or sodium-cooled plants, yet have a relatively low priority in ERDA's program.

SUMMARY

The HTGR has never been accorded the degree of AEC support enjoyed by LWR's, but private and foreign development have brought it to the point where it could become a significant factor. The HTGR and its potential successor, the very high temperature reactor (VHTR), can be used to generate electricity at much higher efficiencies (up to 50 percent) than LWR's, but they may have even greater potential for producing industrial process heat. In addition, they would extend uranium resources and possibly present more easily managed safety and safeguards problems, although the spent fuel safeguards advantage is somewhat counterbalanced by the need to protect the clean fuel. The HTGR, however, is less developed than LWR's, thus presenting cost, performance, and licensing uncertainties.

The GCFR has been viewed as a backup to the LMFBR. It may, however, have sufficient advantages to warrant concurrent development. The breeding ratio is about 1.4, somewhat better than the LMFBR. The thermal efficiency is higher than the LMFBR, and the capital cost could turn out to be lower since the system is inherently simpler. There exists, however, serious uncertainties regarding the loss of coolant accident, since the power density is higher than the HTGR and the core heat capacity is lower, resulting in a faster temperature rise.

QUESTIONS

1. What is the potential of helium-cooled reactors for industrial process heat, both in the medium term as an alternative to coal and in the long term with breeder technology?
2. What is the relative importance of the inherent safety features of the GCFR compared to those of the LMFBR?

BACKGROUND

The HTGR is conceptually similar to the PWR. In current designs of the HTGR, helium at approximately 700° C (1300° F) circulates from the reactor core to steam generators, compared to water at about 330° C (600°F) in PWR's. The gas temperature can be much higher than the water in a PWR because helium remains an inert, single-phase fluid, while water presents corrosion and hydrodynamic problems at high temperatures. The efficiency of the HTGR powerplant is limited by the maximum temperatures and pressures allowed in the steam system, as are fossil units. It should be relatively easy to add a topping cycle gas turbine and achieve efficiencies of up to 50 percent. It would then be advantageous to raise the helium temperature even higher, and 1000° C (1800° F) appears to be feasible.

Industry now consumes about 40 percent of the

Nation's energy, much of this in the form of high-temperature process heat, The HTGR and VHTR appear well suited to provide such heat, and their use could replace the consumption of large quantities of fossil fuel. One potential use is in steam-methane reforming to produce hydrogen for use in coal gasification and liquefaction. Other possible applications are in petroleum refining and chemical industry processing, A process heat reactor would be the first major use of nuclear energy for nonpower use, and many new problems would have to be solved, For instance, an entirely new type of industrial organization would have to learn how to cope with nuclear reactors, and the load-following characteristics in some applications could be much more demanding than in central station power generation.

The HTGR uses mainly uranium-233 as fuel, although the initial core contains highly enriched U-235, The fertile material is thorium-232, which is converted into U-233, corresponding to the conversion of U-238 to plutonium-239 in LWR's and LMFBR's. With appropriate fuel management, as many as eight U-233 atoms can be produced for each ten consumed, Thus, the HTGR utilizes fuel much more efficiently than does the LWR, and this fuel cycle demands much less uranium than that of the LWR, Thorium resources are several times uranium resources, so the use of HTGR's could somewhat postpone the time when breeders are needed, On the other hand, fuel reprocessing facilities are vital to the HTGR, but not the LWR.

The HTGR fuel has significant safeguards advantages over the LWR fuel. The fissile material produced is U-233 rather than Pu-239, Both are suitable for weapons manufacture, but U-233 is much more easily detected than Pu-239 because of its higher gamma ray production, Thus, surveillance and recovery is greatly eased. In addition, *U-233* is far less toxic, so accidental or intentional dispersion is a lesser problem, Some proposed fuel designs, however, leave the fresh fuel in a form that could easily be converted to weapons. This fuel would have to be safeguarded, unlike that of the LWR.

Loss-of-coolant accidents are less severe in an HTGR than in the LWR. The coolant loss rate is slower for the same size pipe break, since the fluid has a lower density, and core heatup is delayed by the graphite in which the fuel is interspersed. Thus a core meltdown is even more improbable,

The HTGR has been commercially available for several years, Several orders were taken for it, but most were deferred or canceled in recent years either because of the general slowdown in the nuclear industry or because of special concerns about the HTGR on the part of the utilities, The Fort St. Vrain demonstration plant *(330* MWe) has suffered from a rash of operating problems which have greatly delayed its power rise. There are also many licensing uncertainties, since HTGR's have not been subjected to the same scrutiny by NRC as LWR's. Initial costs also are high, though there are indications that this problem can be eliminated.

The GCFR is being funded at a much lower level than the LMFBR or LWBR. Much of the technology of the HTGR and the LMFBR will be usable in the GCFR, but the program could be pursued more energetically.

The core of the GCFR is more like that of an LMFBR than an HTGR. The fuel is enclosed in fuel rods, and no moderator, such as graphite, is present, This eliminates the HTGR advantage of slow-heating following a loss of coolant. Helium is a less effective cooling medium than liquid sodium. Hence, the loss-of-coolant accident must be a central design parameter as in the LMFBR.

The GCFR is a natural adjunct to the HTGR, since one GCFR can keep several HTGR's fueled. The breeding ratio of *1.4* results in a doubling time of about 10 years, better than is forecast for the LMFBR with oxide fuels.

The capital costs of the GCFR might turn out to be lower than the LMFBR because the system is inherently simpler. There is still a great deal of uncertainty over this, however, since the technology is not as advanced.

5. Liquid Metal Fast Breeder Reactor

ISSUE

The liquid metal fast breeder reactor (LMFBR) has great potential as an "inexhaustible" long-term energy source, but it poses serious technological and societal problems.

SUMMARY

A successful LMFBR could provide the bulk of the electricity for the United States for millenia at a competitive price. The U-238 which would be used in the LMFBR is readily available and is otherwise useless, Much of the technology has already been demonstrated here and abroad during the past 25 years. Advocates believe that the LMFBR will be an attractive energy source, both economically and environmentally, and that a delay in the present schedule would cause the dissipation of expertise in the development program and probably would lead to a stronger ultimate demand for fossil fuel. In addition, some form of a breeder will be vital if fusion is to be a major source of energy in the twenty-first century, and the LMFBR is the most advanced and promising of the various alternatives.

Opponents of the present plan argue that a year or two delay would make possible a better design, that electric forecasts and uranium reserves do not require the LMFBR on an expedited schedule, that proper safeguards for plutonium will be impossible to design and implement, that plutonium toxicity is not well enough understood, that 1arge technological and economic uncertainties remain, that there will be preferable alternatives, and that proceeding with the Clinch River demonstration will commit the United States so strongly to the LMFBR that it would be commercialized even if it turned out to be a bad choice.

QUESTIONS

1. What steps will ERDA take to resolve the principal safety issues relating to the LMFBR? On what time scale are these issues expected to be resolved, if proposed facilities and programs are completed satisfactorily and on schedule? Does this schedule mesh with ERDA's proposed schedule for developing designs for commercial LMFBR's and for initiating construction of near-commercial plants?
2. How much and what kinds of assistance to industry does ERDA foresee will be required in order to achieve commercial deployment of LMFBR's?
3. To what extent and in what ways does ERDA propose to reduce the cost of LMFBR development in the United States by taking advantage of foreign experience and technology?
4. Why does the U.S. LMFBR program seem to be so much more costly than the very successful French program?

BACKGROUND

The major attraction of the breeder reactor is that it produces more fissionable fuel then it consumes, In the I.MFBR this is accomplished by placing a blanket of Uranium-238 around the core, When struck by a neutron, U-238 generally does not fission as does U-235 or plutonium-239. Instead, it absorbs the neutron and eventually emits two electrons from the nucleus to transmute itself into Pu-239. The core itself consists of fuel rods containing uranium enriched in U-235 or Pu-239 as in an LWR. The familiar chain reaction takes place in the core. On the average, more than two neutrons are produced per fission. One of these is required to produce another fission, and the rest are available for absorption, The LMFBR is designed so that for every atom fissioned, about 1.2 atom of Pu-239 is created. This plutonium can be removed by fuel reprocessing and used to refuel the core, while the excess can be used to fuel an LWR or another LMFBR.

Large quantities of U-238, essentially a waste product of uranium enrichment plants, are now available. When this is exhausted, only small quantities of ore will have to be mined. Since it is worthwhile to mine our vast reserves of low-grade ore for a breeder (but not for the LWR), the LMFBR is for millenia an "inexhaustible" energy source.

There is already substantial experience with LMFBR's. EBR-I produced the first electricity ever obtained from a nuclear powerplant in 1952. Both EBR-II and the Enrico Fermi demonstration plant started up in 1963. The Fast Flux Test Facility (FFTF) is currently under construction at Hanford, Washington, and is scheduled for operation by 1977, The basic purpose of this 400-MW reactor will be the testing of a variety of materials and fuels that can be used in a commercial breeder, The LMFBR has the highest energy priority abroad and plants are being operated successfully in France, England, and the Union of Soviet Socialist Republic,

The prime impetus for developing the commercial breeder is the limited availability of uranium. LWR's require large amounts of uranium, but can only fission about 1 percent of it compared to the LMFBR's 70 percent. Present estimates of high and medium quality domestic uranium reserves and LWR demand show consumption exceeding supply early next century. Some time before then, the fuel price for LWR's will have risen enough so that the higher capital cost of the LMFBR will be justified by its lower fuel cost. The economics of the transition, however, are hard to predict, The capital cost differential will not really be known until a commercial-sized plant is built, but so far none has ever been designed in this country. The fuel-cycle cost of the LMFBR is expected to be extremely low, depending on the actual amount of plutonium produced, but the ultimate breeding ratio (and the future price of plutonium) can still only be estimated. Uranium prices have recently risen sharply, possibly giving credence to fears of a short supply; however, a great deal more could still be discovered, thus delaying the necessity for commercialization of the LMFBR. This topic is discussed in Issue Paper 13. Many cost-benefit studies and discounted cash flows for costs and benefits of the LMFBR program have been made with net benefits varying from over $100 billion to zero, depending upon the choice of parameters with improbable parameters at the extremes.

The growth rate of LWR's is also a critical economic parameter. Critics of the LMFBR program argue that the energy growth rate in general and the electric and nuclear segments in particular must be brought down drastically because of increasingly serious social and environmental impacts, They also point to other industrial nations such as West Germany, where the ratio of per capita consumption of energy to income is much lower than here—thus indicating that the United States should be able to reduce consumption. This would stretch out uranium resources. Advocates of the LMFBR, however, point out that it is by no means clear that the United States can decouple economic growth from energy growth; that large segments of the population still lack energy consuming but desirable amenities; that socially attractive developments, such as electric automobiles and mass transit, will increase demand substantially; and that the imminent shortages of petroleum and natural gas must to some extent be compensated for by electricity.

Emphasis on other types of reactors could slow the consumption of uranium. The HTGR and CANDU can be operated so as to use uranium more efficiently than present LWR's. Their probable rate of penetration into the market, however, is too low to greatly influence the price of uranium. Plutonium recycle in LWR'S would also extend resources about 25 percent as would lowering the U-235 component of the depleted uranium tails at enrichment plants, though this would decrease enrichment output. Both these options would be available later if the need for more LWR fuel appears to be critical and both are discussed in other issue papers.

Some critics also question the quality of the design for the Clinch River (CRBR) demonstration plant. The breeding ratio and reactor safety are specific points mentioned by critics. This 350-MWe plant is designed to demonstrate the licensable nature, operability y, and maintainability of a LMFBR in a utility system. Site preparations for the CRBR has been delayed from 1975 to 1976, to reflect the additional time required to address key licensing and environmental concerns.

Concern over safety has been expressed because the LMFBR, unlike water reactors, is not dependent on moderation by the coolant; hence, a loss of coolant would not directly shut down the LMFBR but would in fact increase reactivity. For this reason, the so-called "core disruptive accident" has been analyzed for the LMFBR in which it is assumed a nuclear transient mechanically disrupts the fuel elements. Energy releases for such incidents have been calculated to be from 100 to a few hundred megawatt seconds for the FFTF, which is equivalent to the energy released by burning 1 gallon of oil or exploding 2 pounds of TNT. Both European and American program experts believe that the chain of events that must be hypothesized for a core disruptive accident to occur is so unlikely that such accidents are not credible. Nevertheless, the reactors are constructed with the capability to contain a wide range of very improbable events, The lack of an inherent shutdown mechanism, however, is troublesome to NRC, which is considering mandating a core catcher for the CRBR. This device would hold the molten fuel in a noncritical configuration if there were a core meltdown. Another strong objection to the LMFBR is the danger of diversion by terrorists of some of the plutonium it produces, Only a very small fraction of the plutonium produced yearly in a breeder economy would be sufficient to construct a crude nuclear bomb capable of releasing energy equivalent to approximately 100 tons of high explosives. It seems impossible to some critics that a safeguards system sufficiently effective to prevent this can be designed and implemented at a reasonable cost and without intruding on the privacy of other citizens. Advocates disagree, saying that the safeguards system which will add only 1 to 2 percent to the cost of power will be reasonably unobstrusive, and will hold the public risks to much lower levels than for other catastrophic accidents. Nuclear parks are a possible partial solution in that the most vulnerable transportation links are eliminated.

The intentional or accidental release of plutonium possibly from a preprocessing of fuel fabrication plant is also a controversial topic. While plutonium is an extremely carcinogenic substance, it is an unlikely terrorist weapon since no effects other than psychological are felt for 25 years, but very tight controls will have to be maintained over all equipment handling it. Safeguards and plutonium toxicity are discussed in other issue papers.

Under normal operation, the LMFBR economy should be environmentally more acceptable than LWR's or fossil plants, The plant itself will have a thermodynamic efficiency approaching 40 percent, equivalent to the best units today. Mining and milling will be virtually eliminated. The environmental objections center mainly around the safety and safeguards problems already discussed.

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6. Light-Water Breeder Reactor

ISSUE

The light-water breeder reactor (LWBR) concept has several advantages, but the need for it is questionable.

SUMMARY

The LWBR is the only breeder reactor now being seriously pursued by the United States that uses thorium rather than uranium as its primary fuel. The technology of the LWBR is based on that of the main line light-water reactor; the original idea of the LWBR is that it would afford an all but inexhaustible source of energy yet would require relatively little development, About $25 million per year has been spent on this concept for the past 9 years, and a demonstration LWBR is expected to operate in the pressurized water reactor vessel at Shippingport, Pa., by 1976. If a 1,000 MWe LWBR over 30 years requires as little as 1,500 tons of uranium, rather than the 3,000 to 5,000 required of other reactors, it could become a serious contributor to the nuclear energy programs, yet in the ERDA nuclear program there seems to be no mention of LWBR actually carrying some of the nuclear load at any time, and utilities have shown little interest in the concept.

QUESTIONS

1. Why is LWBR not mentioned in ERDA projections of future nuclear mixes?
2. What measures does ERDA intend to take to make LWBR technology more accessible to possible users of this reactor type?
3. At what uranium price and rate of deployment does the LWBR look attractive?
4. Does ERDA intend to make a detailed economic assessment of the LWBR fuel cycle?

BACKGROUND

The LWBR was conceived in 1965 as a simple, inexpensive way of breeding in the thorium cycle that did not require new and unproven technology, The fundamental idea was to replace the slightly enriched U-235-U-238 fuel elements in a PWR with "seed blanket" fuel modules: each module consists of thorium-U-233 fuel rods (seeds) surrounded by thorium rods (blankets). The normal fissioning process takes place in the seed rods, Neutrons produced in the seed are caught in each blanket and thorium there is converted into U-233. It is estimated that breeding ratios of around unity can be achieved with this arrangement.

When the LWBR was first proposed in 1965, it seemed to defy most of the precepts set forth for a good breeder: high breeding ratio; low inventory of fissile material; high thermal efficiency; simple fuel recycle. The one countervailing advantage was that the LWBR largely used standard pressurized water technology, and therefore it could be developed for a fraction of the cost of any other breeder, such as the LMFBR. The AEC, in weighing the matter, decided that the simplicity of the technology outweighed all other considerations, and it assigned the task of developing the LWBR to the Naval Reactor Branch under Admiral Rickover. The LWBR is now at a point where a demonstration of the principle is about to be made in the Shippingport, Pa. reactor facility.

Originally, it was hoped that utilities would find the concept interesting as a means of transferring easily from the standard PWR to a breeder without having to switch to a completely different technology. Thus far, utilities have shown little interest in LWBR, primarily because LWBR fuel-cycle costs were estimated to be much higher than PWR fuel cycle costs; and, second, because so little hard information has been made available about the LWBR.

The rapid rise of capital costs and the approaching shortage of uranium may have improved the commercial outlook for the LWBR. Because of the higher capital costs, fuel cycle costs (which are probably high in LWBR) are no longer so important; and the shortage of uranium may make even the fuel-cycle cost of LWBR's competitive, especially if prorated over 30 years, during which time the uranium shortage may become acute.

There still remain a number of technical uncertainties. For example, the LWBR has a more tightly packed lattice than PWR's which may cause some difficulty with the emergency core cooling system; there will probably be less power output for a given core size compared to a LWR; the breeding ratio is so close to unity that LWBR may turn out not to breed at all. The initial loading of uranium in a LWBR is much higher than in a PWR; hence, an expanding LWBR economy may place even heavier demands on total uranium resources during the first several decades. The purpose of the Shippingport test is to prove the feasibility of light-water breeding. Full technological development and economic development will require a substantial R&D program.

However, the situation since the LWBR was first proposed has changed sufficiently that it seems prudent to consider LWBR to be a more serious contender than has previously been the case, Information on LWBR will soon be available in the Environmental Impact Statement so that potential buyers of LWBR's can assess the system more realistically.

7. Molten Salt Breeder Reactor

ISSUE

Support for the molten salt breeder reactor (MSBR) development program is small compared to other reactors and maybe insufficient to permit evaluation within a reasonable time period.

SUMMARY

The MSBR program is presented by ERDA as a potential backup for solid fuel breeder reactors. It uses an inherently different nuclear technology, and hence provides technological insurance, Even if fast breeder reactors prove to be commercially successful and environmentally acceptable, the MSBR, based on thorium rather than uranium, would enlarge the options available for future energy systems and offer substantial advantages such as more easily managed safety and safeguards problems, There are unique problems associated with the development of the MSBR, however, which must be solved.

QUESTIONS

1. What are the major milestones seen by ERDA in the MSBR program?
2. What criteria will ERDA use in deciding whether or not to continue the program?
3. Is the funding level proposed by ERDA ($3.5 million adequate to reach a meaningful decision point in FY 77, as suggested by ERDA?
4. What level of funding would be required to maintain the MSBR program as a realistic alternative to the fast breeder reactor program, so that commercial deployment of MSBR's could be undertaken by the end of the century, if needed?
5. Would the MSBR be more secure than solid-fueled reactors against diversion of fissionable material for unlawful purposes?

BACKGROUND

The MSBR offers the possibility of a significant breeding gain in a thermal-neutron reactor using thorium rather than uranium as the basic fertile material. To reach self-sufficiency (ability to fuel its own growth), an economy based on the MSBR would probably require no more natural uranium than a fast breeder reactor economy if deployed at a comparable rate. Its advantages are a short fuel cycle, fast reprocessing, low fuel inventory, and high thermal efficiency. The disadvantages of the MSBR are high tritium product ion, chemical complexity, and more extensive requirements for remote maintenance of radio active components, since contamination is heavy throughout the entire reactor system. Fuel reprocessing is done by continually withdrawing a small amount of the molten fuel, removing the fission products and excess uranium-233 and reinfecting the clean fuel, Thus, the fuel in the reactor at all times has a low inventory of fission products, which are the major potential source of safety problems in solid fuel reactors. The safeguards problem may be reduced because the fissionable fuel produced by the MSBR is much less toxic and more easily detected than plutonium. The fuel recycle process would be part of the reactor plant; successful development of equipment for this is an essential part of the MSBR program.

Molten salt breeder reactor technology has been under development for more than 20 years. Two reactor experiments have been operated successfully: the Aircraft Reactor Experiment (ARE) in 1954, and the Molten Salt Reactor Experiment (MSRE) in 1965-69. Key areas in which further development is needed are listed below:

- Graphite moderator (reduced sensitivity to irradiation)
- Structural metal (reduced sensitivity to chemical attack by fission products such as tellurium)
- Retention and control of tritium
- Chemical processing (materials for equipment and processing)
- Component development, including equipment for removal of fission-product gases from the fuel salt.

Recent funding has been at $3.5 million per year, This is far less than any other reactor concept currently funded by ERDA. Problems are being addressed, but at such a low level that even determining the potential for solutions is far off.

8. Nuclear Environmental Effects

ISSUE

There is a continuing need for the evaluation of the environmental effects associated with nuclear energy sources.

SUMMARY

In the establishment of biomedical and environmental research priorities, ERDA has not identified clearly the continuing efforts needed in the assessment of environmental issues associated with nuclear-based technology. These efforts must be maintained on long-term studies of radionuclide accumulations and recycling in the aquatic and terrestrial environments, Other programs that should receive increased attention are concerned with reprocessing facility releases and impact/recovery studies of accidental releases from reprocessing facilities and reactors to local or regional areas.

QUESTIONS

1. In order of priority, what are the remaining questions connected with the environmental impact of nuclear energy?
2. To what extent is ERDA investigating the range and historical relationships of radionuclide concentration factors in aquatic environments?
3. How does ERDA evaluate the economic consequence of accidental releases that would restrict agricultural operations?

BACKGROUND

The use of nuclear fuel sources, as well as other energy sources, is associated with environmental interactions, most of which are either well known or predictable. Both aquatic and terrestrial ecosystems are affected to various degrees.

Relatively large volumes of water are required for cooling purposes. Depending upon cooling water intake structural design and location, the effects upon entrained aquatic life are highly variable, with mortalities ranging from 10 percent for well designed and sited once-through systems to as much as 100 percent for low consumption closed systems. In addition, heated water, metallic corrosion products, low-level radioactive wastes, and water treatment chemicals may be discharged to surface water ecosystems. Where evaporative cooling is employed, the same pollutants are discharged at lower volumes and temperatures but at greater concentrations than with once-through cooling.

The use of large, evaporative cooling towers results in the atmospheric dispersion of large volumes of heat, moisture, salts, and a variety of chemicals which interact with the terrestrial environment as well as the atmosphere. This is true for both nuclear and fossil plants, but nuclear requires more cooling for the same power and, also results in the release of low levels of radioactivity y. Released either to receiving waters or atmosphere, these interact with man and either directly with terrestrial or aquatic ecosystem components or indirectly through a synergism with other plant releases, such as heated plumes (aquatic or atmospheric) metals, and chlorine. Depending upon the type of meteorologic or hydrologic transport of these low-level radioactive products, they are available for uptake, cycling, and concentration within biological food chains which include man.

Since ERDA's Plan envisions many new nuclear energy sources, adequate resources must be devoted to the associated environmental problems. The environmental study program, however, appears to shift emphasis from nuclear to fossil power. This is reasonable because nuclear environmental and health hazards are probably better understood than those from other sources, although many uncertainties remain even here.

Specific data deficiencies also exist, such as the biological cycling of low-level ionizing radiation within various aquatic ecosystems, Studies are needed to assess the patterns of accumulation and resultant effects on the aquatic community, as well as any resultant hazards to man.

Another area for research concerns localized accidental releases around operating nuclear reactors and reprocessing facilities. Insufficient effort has been devoted to the specific economic, sociological, and radiological impacts that apply to the population groups involved. In particular, there is need for a better understanding of remedial measures available and their resultant cost/value relationships.

9. Plutonium Toxicity

ISSUE

The toxicity of plutonium may pose a serious threat to a plutonium-based nuclear option, such as the LMFBR or plutonium recycle in light-water reactors.

SUMMARY

Suggestions have been made recently that plutonium may be much more hazardous than had been previously believed to be the case. Though these claims have been specifically denied by the British Medical Council, to ERDA scientists, and many other scientists and scientific groups, the issue remains a lively one requiring a more definitive resolution than exists at present.

QUESTIONS

1. How much effort is ERDA planning to devote to resolution of the question of toxicity of plutonium?
2. What is the evidence that land contaminated by plutonium can be restored to a usable condition?

BACKGROUND

Plutonium is a very hazardous material; for example, the maximum permissible concentration of the isotope Pu-239 in the air, when the plutonium is in the form of insoluble plutonium oxide, is about 6×10^{-14} microcuries per ml or 100 x 10-20 gin/ml. Nevertheless, other materials (such as the botulism virus) are much more toxic per gram than plutonium. Fortunately, plutonium is not readily absorbed by the gastrointestinal tract or by the food chain.

Inhalation of radioactive discharges from nuclear facilities is the more likely mode of significant plutonium ingestion. This results in deposition in sensitive lung tissues with possible ultimate development of lung cancer. The maximum permissible lung body burden is 1 6 nanocuries; however, various critics of the nuclear energy program have argued that this body burden is too high by a large factor.

The position of the nuclear energy community and of the majority of qualified experts in the biomedical community is that currently allowed levels are safe. Primary evidence for this conclusion is that, despite man having dealt with plutonium on a large scale for over 30 years, no case of lung cancer in man can be attributed to plutonium. In particular, some 25 workers at Los Alamos received as much as 10 times the occupational dose limit to the bone, yet some 30 years later none of these people has suffered ill effects. Critics claim that these findings are not in conflict with their position because the doses were not received in the most dangerous manner,

10. Waste Disposal

ISSUE

Satisfactory handling of nuclear fission wastes appears to be technologically feasible, although it has yet to be demonstrated. Other problems exist, mainly societal and institutional, which greatly influence the nature of the demonstration required.

SUMMARY

Spend fuel discharged from a reactor contains radioactive fission products which must be isolated from the biosphere for approximately 700 years as well as actinide elements (uranium, plutonium, americium, curium, and other heavier elements) which are radioactive for hundreds of thousands of years. Because there are no chemical reprocessing plants currently operating in the United States, spent fuel elements from nuclear powerplants are stored temporarily in water basins at the powerplants. Commercial facilities are being designed and constructed, however, to receive the spent elements and remove almost all of the uranium and plutonium, which can be recycled into new fuel, while the residue must be disposed of in solidified form. Several options for this exist, each with different short and long-term economic and societal costs and benefits, If the wastes are sequestered without further separation, the long-term radioactivity between 700 and about 1,000,000 years of the approximately 1 $meter^3$ per reactor-year is several times that of natural pitchblend ore; but if diluted to the original volume of mined uranium ore, the radioactivity is less than that of the ore. If the actinide elements are also removed during reprocessing and recycled and "burned out" in the reactor itself, the toxicity after 700 years is essentially negligible thereafter.

Projected costs for almost all the water disposal options are small compared to the total value of associated power produced.

QUESTIONS

1. What program exists to evaluate the hazards and options associated with nuclear wastes and at what level is this program funded?
2. What are the expected total hazards from the various main options for nuclear waste disposal?
3. What reservations does ERDA have concerning the disposal of solid waste in salt formations (as at Carlsbad, N. Mex.)?
4. How does the scheme for burning out the long-lived transuranic elements in a reactor compare with other options?
5. What is to be done about the so-called alpha wastes (e.g., plutonium-contaminated tools, gloves, etc.) where the activity per unit volume is low, but the volume is so large that total activity is comparable to the high-level wastes?

BACKGROUND

For permanent disposal of wastes, present options are as follows:

. Disposal of wastes as presently envisaged to be processed in sites with very high integrity up to 700 years or so, with integrity at longer times striven for, but not essential to guarantee, The present disposal-in-salt schemes seem satisfactory provided obvious mistakes such as susceptibility to intrusion of ground water are avoided.

- Better removal of the long-lived radioactive wastes; specifically, the 0.50/0 remaining plutonium, plus the bulk of americium, curium, etc., which are now normally left in the wastes, The impact of such extra separation on the total fuel cycle cost is uncertain, but quite possibly modest, The separated long-lived wastes would then have to be burned out by reinsertion into operating nuclear reactors (fast reactors would be best). If this option were developed, the long-term storage problem would be virtually eliminated, and the shorter-term storage problem would become even more straightforward.

- Disposal of untreated wastes in hitherto relatively unconsidered locations: for example, burial in ocean floors, Many of these geologic regions have been stable for many millions of years, and modern deep ocean drilling techniques have improved substantially in the last several years.

Presently contemplated chemical reprocessing methods for spent fuel elements are expected to remove *99,50/0* of the plutonium and uranium and little of anything else; this procedure represents the best macroeconomic profitability because of the value of these materials for recycling. Substantial quantities of radioactive heavy elements americium and curium with half-lives of *10,000* to *25,000* years would remain with the fission products, whose half-lives are less than *50* years. Since ten half-lives reduce the original activity by a factor of a thousand, which is usually a safe level, **700** years' isolation is adequate for the fission products as contrasted with 200,000 years for the heavy elements,

Inclusion of a further reprocessing step, which would remove these heavy elements from the fission products, appears feasible, Because the heavy elements are small in volume, they can probably be returned to a fast reactor to be fissioned, at which point they become normal fission products. Thus arises the question of present costs versus far future benefits.

In any event, the wastes must have low leachability y. This can be assured via well developed waste technology. Evidence that such low leachability can be achieved, even without any processing or conversion to solid form, is provided by some ancient "natural reactors" in Gabon which have been under study by French scientists. Neither plutonium nor other long-lived wastes were found to have migrated appreciable distances since ancient geologic times, as evidenced by the fact that their final decay products are spatially coincident with the remaining uranium.

11. Safeguards for Nuclear Materials

ISSUE

Safeguards must be adequate to prevent the theft or loss of fission materials, with subsequent clandestine construction of nuclear weapons.

SUMMARY

Only about 20 pounds of reactor grade plutonium oxide, or comparably small quantities of other fissionable materials, are required to make a crude nuclear bomb. Furthermore, the information needed to design and construct nuclear weapons is readily available. Preventing diversion of small amounts is difficult because fissionable material must be processed and handled in multiton quantities annually. Plutonium, which is already produced in large quantities in light-water reactors, is an even larger component of the LMFBR fuel cycle, While it is widely agreed that pas t safeguards practices have been inadequate, a number of measures are under consideration to improve the safeguarding of nuclear materials in the United States. There are important international aspects to the problem, however, since, once diverted, the materials are rather easily concealed and transported.

QUESTIONS

1. What extra safeguards are needed to protect plutonium from being stolen from fuel fabrication and reprocessing plants by heavily armed gangs?
2. Is ERDA studying or developing new safeguard techniques?
3. To what extent would the safeguard problems be eased if the entire nuclear power program were shifted from uranium-plutonium to thorium-uranium?

BACKGROUND

The information needed to design and construct crude nuclear weapons is available, as are the associated nonnuclear materials required. Dozens of nations have the skills and facilities necessary to build reliable atomic bombs. Some, but not all, nuclear weapons experts assert that small groups of people, conceivably even individuals, could construct a crude bomb which, although inefficient, could be transported in an automobile and would be highly destructive. Furthermore, modest workshop facilities would suffice. Such a crude bomb might have the power of 100 tons of TNT and, if exploded in a densely populated city area, might kill more than 100,000 people under some circumstances.

The only ingredient not readily available for such weapon construction is the nuclear fissionable material required. A few tens of pounds of plutonium or highly enriched uranium are needed, the exact amounts depending on the chemical form and the degree of dilution of the fissionable isotope with nonfissionable isotopes. Such plutonium or enriched uranium is used or produced in most fission power reactors.

Plutonium is also a potentially toxic material. If dispersed in the form of small particles in the atmosphere with sufficient concentration, inhalation might lead to many eventual deaths from cancer. The potential threat in populated areas should be compared with the corresponding threat of dispersal of highly poisonous chemical or biological agents, except that physical effects are not generally visible for several decades. Thus, the primary threat as a terrorist weapon is psychological.

In addition to the countries which already have nuclear weapons, 15 others operate power reactors which produce plutonium. By 1985, the number will be at least 50. The plutonium produced will be in the irradiated fuel rods and, therefore, will be in too dilute a form for a bomb. These rods will also contain highly radioactive and dangerous fission products whose radiation will play an effective "self protecting" role so that clandestine theft and handling would be very difficult. This situation changes when the fuel elements are reprocessed and the plutonium is separated from the other elements; several countries have or are constructing nuclear fuel reprocessing plants,

The International Atomic Energy Agency (IAEA) in Vienna has the responsibility for safeguards to detect the diversion of nuclear materials from peaceful purposes in nations that are parties to the Treaty of Non-Proliferation of Nuclear Weapons or have otherwise agreed to have their civilian nuclear materials under international safeguards. The responsibility for applying physical security safeguards to prevent theft or diversion of nuclear material by clandestine groups belongs to the individual countries involved.

In the United States, the present physical security for civilian nuclear materials, though strengthened substantially during the last 2 years, may still be inadequate to prevent theft by heavily armed groups with adequate resources and motivation comparable to the Brinks gang, NRC is presently studying new regulatory actions which involve "the principle of contain-merit, " in that all potentially explosive fissionable material will be handled in areas circumscribed by well-defined barriers. A limited number of channels for the flow of materials through the barriers and other channels would be continuously monitored.

Some of the new safeguard measures under consideration are:

- Collocation of fuel reprocessing and fuel fabrication plants.
- Dilution of the separated plutonium by uranium at the output stages of reprocessing plants. To produce explosive fissile material chemical separation would then be required, and the weight of the material which must be stolen would be increased by a factor of about 100,
- "Spiking" of the plutonium with dangerous radioactive materials. Massive shielding would be required for all subsequent handling.
- Limited "spiking" of the plutonium with radioactive materials to make detection easier by monitoring systems.
- Use of specially designed vehicles or heavy containers for shipment.
- Establishment of a Federal protective service to safeguard nuclear materials in transit,

It is estimated that the cost of implementing these extra safeguards, although high, would increase the cost of the nuclear electric power by no more than 15 percent,

12. Siting

ISSUE

Nuclear Regulatory Commission policy changes for siting could influence reactor and supporting system design.

SUMMARY

The Energy Reorganization Act (ERA) of 1974 calls for the Nuclear Regulatory Commission (NRC) to report to the Congress on the clustering of nuclear reactors and supporting facilities in "nuclear parks. " Nuclear parks offer several advantages: easier safeguarding of fissionable material, lower unit construction cost, probably increased safety, and less disruptive construction (since the work force is stable), Disadvantages include higher vulnerability in the event of war, creation of heat islands, and increased expense of transmitting power from the remote site. If nuclear park siting becomes a general practice, certain technical problems would require more serious study and resolution: electrical transmission of extremely large blocks of power; the simplification of transport systems between reactor and chemical plant; the incorporation of interim waste disposal facilities on the nuclear park site; and the design of different reactor systems that are better suited to park siting, Though siting policy and the possibility of nuclear parks is largely the responsibility of NRC, the matter is so vital to the entire future of the nuclear energy enterprises that ERDA should be strongly involved in the development of the concept from the beginning.

QUESTIONS

1. If nuclear parks siting is required, how would this affect (a) the ERDA safeguards program; (b) the types of reactors ERDA develops; (c) the transport systems ERDA develops; and (d) the climatological effects program of ERDA?
2. Is ERDA planning to examine the social and institutional implications of nuclear parks?
3. Does ERDA believe that breeder reactors and their subsystems should be confined to nuclear parks?

BACKGROUND

When large-scale nuclear energy began in the United States during World War II, nuclear reactors and their chemical plants were confined mainly to nuclear parks: Hanford, Wash,; Savannah River, S, C,; Oak Ridge, Term,; and Idaho Falls, Idaho, In the ensuing 30 years, this original practice has been replaced by scatter-siting, The reactor has not been viewed as part of a system, but as a replacement for the boiler in a conventional steam plant.

With increasing popular concern about nuclear energy, the idea of nuclear park siting has received increasing attention as a means of answering some of the objections to nuclear energy. The feasibility of nuclear parks is now being studied under the auspices of NRC, and it is not clear what role ERDA ought to play in the clarification of the problem. There are some react or configurations— MSBR, the coupled HTGR-GCFR, 'and possibly the LMFBR—that might better be located in parks than in isolation.

Nuclear park siting would carry with it many institutional implications: utilities might have to cooperate to support such large enterprises; the generation of electricity would tend to be separate from its distribution; and land use planning over a very longtime would be required. The impact on reactor design and selection is such that the possibility should be considered in present nuclear R&D programs and planning.

13. Uranium Resources

ISSUE

The lack of precision in present uranium resource estimates and questions as to the rate of expansion of uranium production capability make resource-related issues difficult to address.

SUMMARY

Since the adequacy of the domestic uranium resource base has an important bearing on ERDA's and utilities' nuclear strategy, and especially on the timetable for breeder reactor development, a much more precise evaluation is needed then is presently available or anticipated. To keep pace with the Nation's energy needs as projected by ERDA, substantial expansion of domestic uranium production over the next 25 years will be required. This entails long leadtimes, major capital expenditures, and in the relatively near term, large exploration effort and ore-body development. The long time, perhaps 10 years, required for the development of a new mine-mill complex, together with the existence of competing investment opportunities, may require the creation of a relatively low-risk investment climate through loan guarantees, accelerated depreciation regulations, and assured uranium markets. Market prices have increased dramatically during the 1973-75 period from $7 per pound of U_3O_8 to about $30, and there is no reason to expect an early end to the seller's market,

QUESTIONS

1. Is the National Uranium Resource Evaluation (NURE) adequately funded to meet the need for the identification of assured reserves for the next 30 years?
2, What is ERDA's program for obtaining uranium resource information for its data base which is held in the private sector?
3. What incentives are needed, if any, to stimulate substantially greater exploration and development of mining and milling operations to insure the future availability y of fuel supplies?
4. How does ERDA evaluate the impacts of dependence on foreign sources of uranium, exportation of domestic uranium, and the participation of foreign interests in domestic resource development.

BACKGROUND

The adequacy of the domestic resource base has an important bearing on ERDA R, D&D strategy—in particular, the timetable for breeder reactor development and application. Also, utility perception of the resource base may condition the pace of utility commitments to nuclear power in the prebreeder era, As matters now stand, information needed for a definitive assessment of the domestic resource base is lacking, and expert opinion on the question of its extent is divided. ERDA's NURE program, initiated in 1973 and targeted to be completed by 1980, represents the first attempt to develop a comprehensive analysis of domestic uranium resources and hopefully will bring the question of adequacy into clearer focus. Work being carried out by the U.S. Geological Survey (USGS) will contribute additional insights, but is by no means clear that the sum of the ERDA, NURE, and USGS activities can or will provide all of the answers needed.

To keep pace with ERDA requirements projections, the domestic uranium production industry will have to expand at a very substantial rate, For example, ERDA's so-called "medium low" projection defines the growth in annual requirements as follows:

Year	Tons of U_3O_8
1975	10,000
1980	19,000
1985	37,000
1990	61,000

These figures assume recycle of uranium and plutonium, starting in the late **1970's.** Requirements would be about 25 percent higher than indicated here without recycle.

In 1974, the domestic industry produced 13,000 tons of U_3O_8. It is estimated that a 25,00()-ton per year production level could be realized if the domestic industry were to proceed with mine/mill ventures to exploit ore bodies already largely developed. Significant expansion beyond that level hinges on the results of exploration effort and ore-body development in the years immediately ahead, The leadtimes entailed are appreciable, and the capital requirements are substantial.

An appreciable part of the upward price movement of uranium since 1973 is a necessary and long overdue adjustment from an artificial uranium price economy to one that provides a reasonable incentive for supply industry expansion. At the same time, some portion doubtless reflects the existence, since mid-1973, of a strong sellers' market atmosphere, in which the quantities of low-cost reserves which suppliers have placed on the market are limited in relation to the quantities utilities would like to purchase.

During the interval to the end of the century, the typically projected annual ore production requirements will increase by a factor of roughly 10, which is more than twice as fast as the most rapid growth phases of other significantly large mining industries (such as copper) in the United States. The general resource shortages in the next few decades should provoke caution in the expectations that the required exploration crews, drill rigs, mine-mill investment capital, miners, and geologists will become available as needed,

The following factors are also potentially significant in affecting whether adequate fuel supplies will be available, and they merit attention in any coordinated national energy strategy:

- The recent occurrence of increased delays and costs in exploration and development activities because of new State and Federal environmental protection requirements [such as the NEPA statement).
- The need for improved geological models and exploration equipment (such as more sensitive, lightweight, airborne gamma-detectors).
- The abandonment of mines depleted of currently economical ore.
- The increased ore requirements which will be imposed if the ERDA-announced plan to increase the tails assay of the U.S. enrichment plants is implemented, if Pu-recycle is indefinitely delayed, or if the HTGR is not eventually commercially successful,

14. Uranium Enrichment

ISSUE

Expansion of uranium enrichment capacity is required to meet domestic requirements and foreign commitments for LWR and HTGR fuel.

SUMMARY

Enriched uranium fuel is needed in light-water reactors (LWR) and high temperature gas-cooled reactors (HTGR). The existing ERDA diffusion plants are being upgraded and expanded, but their capacity will be exceeded within a decade if presently contemplated nuclear powerplant construction occurs. ERDA policy calls for development of new production facilities by the private sector, but the financial risks may be too great without some form of Federal economic assurance. Among the risks involved in the financing of new plants is the possibility that new technology, such as the gas ultra-centrifuge or laser separation, might render a new diffusion plant obsolete. A related management question concerns the proposal to allow the U-235 content of the enrichment plant by-products material ("tails") to increase, thereby producing increased enriched uranium output at the expense of greater natural uranium input.

QUESTIONS

1. What financial and technical arrangements are required to bring a private enrichment plant on line at an early date?
2. How and when will ERDA make its centrifuge and laser isotope separation technology available to industry, and what effect will this have on the development of a centrifuge enrichment industry?
3. What are the implications for nuclear weapons proliferation in the advanced enrichment technologies?

BACKGROUND

Before the mid-1980's, ERDA will have upgraded U.S. enrichment capacity to support the generation of approximately 320,000 megawatts of electricity (MWe) if other fuel-cycle factors develop favorably. This capacity has already been unconditionally committed (208,000 MWe domestic and 107,000 foreign), and there are conditional foreign contracts already in hand that could increase the load by another 14,000 MWe. There is a clear need, therefore, for additional enrichment capacity to be completed by 1985, and perhaps earlier if other fuel-cycle factors develop less favorably than presently anticipated. These factors include delayed plutonium recycle, lower U_3O_8 production capability and higher LWR capacity factors. Enrichment capacity can be easily expanded by increasing the tails assay. This means that a given batch of uranium is not wrung out as hard as possible, but is replaced by new richer feed sooner.

The proposed change of enrichment tails from

0.2 to 0.3 percent U-235 would increase the existing enrichment capacity by 20 percent. The drawback is that the incoming feed of uranium must be increased by a similar factor, The enrichment cost would decrease, while the increased feed requirement would stimulate increased exploration and ore production. Opponents of this proposal argue that it represents false economy, in that it effectively reduces the long-term uranium supply for the LWR and HTGR, and that uranium production capacity already will be strained in the period when enrichment capacity will become critical.

The need to begin construction of a new enrichment plant is urgent, since construction time is estimated (by the National Petroleum Council) at 9 years for private construction, 6 to 7 years for the Government. Financial backing for an additional diffusion plant has so far been unavailable to industry because of several factors: high cost, about $3,5 billion for a $9-million separative work unit per year plant; the presently low pricing by existing ERDA facilities; and the threat of early obsolescence induced by the gas ultra-centrifuge and laser isotope separation. Possible Government assurances to induce industrial participation are guaranteed price for the product, guaranteed construction loans, and a change in pricing policy for enriched uranium from existing plants.

Of the new technologies, laser isotope separation is a promising concept but not yet even at the pilot-plant stage and there is no assurance of increases. Both this and the centrifuge process promise such substantial reductions in costs, as well as in the minimum scale for economical operation, that they represent a potential international threat through the clandestine production of nuclear weapons materials, As with gaseous diffusions, much of the information related to both processes is classified.

Gas centrifuge technology is well advanced, but a large-scale commercial plant has not yet been constructed. A major advantage to this process is its substantially lower electric power consumption, about 10 percent of that by a comparable diffusion plant. A Western European consortium has developed the process, and plants have been built in the Netherlands and the United Kingdom, Although classified, this technology is presumably available to the United States under bilateral agreements. In addition, the United States has a classified centrifuge program which is generally believed to be superior to the European technology and may be at the stage to support production plant construction.

15. Fuel Recycle

ISSUE

Fission fuel recycling capability is needed for the orderly development of nuclear power.

SUMMARY

Spent nuclear fuel assemblies still contain much valuable fuel material, The discharged fuel can be reprocessed to recover the usable fuel material, which can then be recycled through a reactor, There are four basic reasons for recycling the fuel: (a) the recycled fuel reduces the demand for new uranium that would have to be mined and refined; (b) recycling, desirable for LWR's, is an economic necessity for HTGR's, LMFBR's, and other advanced reactor designs; (c) lower power-generating costs should result; (d) the chemical processing which is part of recycling is also an integral part of some of the more promising waste disposal schemes,

Recycling is, however, beset by several problems. First, a reprocessing, a refabrication, and a radioactive waste disposal industry must be constructed and operated. Second, safeguards and transportation must be developed to protect the material adequately. Third, the economic advantage of recycling in LWR's is small at best although the spend fuel still contains material that can produce a large amount of energy.

The central point is whether ERDA's budget is adequate to develop the necessary recycling capability or whether adequate incentives can be provided to industry to provide this capacity,

QUESTIONS

1. What are the implications for resource economics and safeguards if recycle is further delayed?
2. What safeguards programs will ERDA support for reprocessing plants, plutonium shipment, and mixed-oxide fuel fabrication?

BACKGROUND

During the last decade, major emphasis in the nuclear field has been in reactor development and in the "front-end" of the fuel cycle. This emphasis was necessary to transform raw uranium ore into fuel *that* could be used in the reactors. The "back-end, " consisting of reprocessing, refabrication, and radioactive waste disposal, was not stressed; the AEC may have felt that these operations should be developed by private industry or that there was no urgency involved.

The arguments for recycling center on the conservation of uranium resources, the anticipated economic savings, radioactive waste handling, and the economic necessity for recycling in HTGR's, LMFBR's, and other advanced reactor designs, The lifetime 1,000 MWe LWR requirement for yellowcake (U_3O_8) is 5,400 short tons with no recycling, or 3,800 short tons with recycling. This results in a uranium savings of 30 percent over the reactor lifetime, For reactors

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other than LWR's, the economic savings are substantial; even for the LWR, recycling fuel is expected to offer an economic advantage. A recycle industry will definitely be needed in the future if a reactor concept other than the LWR is deployed, since the economic advantage of these advanced reactors hinges on the ability to recycle fuel.

Three companies—Nuclear Fuel Services, Allied-Gulf Nuclear Services, and General Electric—entered the reprocessing business, but presently no plant is operating, even though all three companies have contracts for reprocessing spent nuclear fuel in the *1970's*. General Electric practically completed their plant at Morris, Illinois, but found that certain advanced design features limited the throughput to noneconomic levels; they are now evaluating possible courses of action and hope to make a decision by the end of 1975.

The Nuclear Fuel Services plant operated from 1966-72 and reprocessed about 600 metric tons of fuel. Since 1972, the plant has been shut down to upgrade its radioactivity control systems and to consider designs to increase throughput, An application for a construction permit to carry out this expansion has been submitted, and the plant could be operational in the *1980's* if the licensing process is continued. The Allied-Gulf Nuclear Services plant, which is 95 percent complete in its basic structures, is now awaiting its operating license. Similarly, large-scale commercial refabrication plants are not operating, although several private pilot plants are in operation.

Because of substantial cost increases associated with newly implemented regulations, high construction cost escalation, and risk allowances to cover future uncertainties, the recycle of LWR fuel has lost much of its economic attractiveness. However, spiraling costs for raw uranium and for enrichment may change the economic picture.

ERDA, in a report (ERDA-33) on the problems of the fuel cycle, reviews this situation. They are concerned that a number of key process steps in the reprocessing plants are still undemonstrated, such as conversion of plutonium nitrate to solid form accept able for shipment, increased safeguards, waste solidification and packaging for shipment to storage/disposal facilities, and the removal and packaging of certain radionuclides from process streams to meet site effluent limits,

16. Public Understanding

ISSUE

Public understanding of the energy problem, and especially of the nuclear option, receives minor emphasis in the ERDA Program.

SUMMARY

The energy problem is complex, and increased efforts must be directed toward better public information programs. Within the past several years, public anxiety, confusion, and doubts have increased, and the energy problem is widely perceived as a "contrived situation. " More effort must be directed toward better understanding of energy options so that well-informed energy decisions can be made by the public. One of ERDA's tasks is to create and encourage ". . . the development of general information to the public on all energy conservation technologies and energy sources. . ." In addition, the ERDA Administrator, in conjunction with the FEA Administrator, is directed to disseminate such information through the use of mass communications. (Section 103. i' of Public Law 93-577.)

QUESTIONS

1. What type of program, with what budget level, will ERDA use to increase the public understanding of energy options?
2. How does ERDA envision the promotions of nuclear power being handled in the Government as compared to the development, and how will the agencies involved coordinate their roles?

BACKGROUND

There is great uncertainty among the public about the energy options that are being selected, but little effort seems to be directed toward the development and dissemination of information on energy issues. The nuclear field is poorly understood, even by otherwise well-educated people, and nuclear technology is widely mistrusted among the public. The task of providing adequate information for informed choices is formidable.

Another source of public concern may be the outgrowth of military needs. Although the nuclear industry has matured and has largely divorced itself from its military origin, the problem of safeguarding fissionable material to prevent illicit weapons production retains military implications. This subject is treated in more detail in Issue Paper 11 on "Safeguards. "

In addition, past practices of the AEC may be partially responsible for public mistrust. The former agency tended to be secretive and did not always respond fully to public requests for information. Reports and internal memoranda were suppressed, and the Commission's dual role of promoter and regulator resulted in criticism of the agency's objectivity. Understandably, the public is suspicious when a topic is surrounded by secrecy. A more basic problem is that the very technical, complex nature of nuclear science and technology prohibits easy explanations to seemingly simple questions.

Although most people who are knowledgeable in the nuclear field favor the continued development of commercial reactors and believe that both reactor safety and nuclear safeguards questions are resolvable, there are some experts who disagree and who advocate a slowdown or cessation of reactor procurement. The controversy is complicated by the fact that most pro-nuclear experts, of necessity, are employed in the industry, by ERDA, or in university programs partially dependent on ERDA. As a result of the lack of scientific consensus, the concerned layman may be at a loss for an informed judgment. The advantages and problems of nuclear power compared to other options must be thoroughly aired for the public to make rational choices,

17. Controlled Fusion

ISSUE

Great care must be exercised to ensure that the ERDA-controlled fusion program does not expand at a rate so fast that proper attention is not given to the different physics problems of controlled fusion and that development of new concepts is not prematurely abandoned.

SUMMARY

The advantages of successful fusion power are great; fusion research needs should receive high priority, but success is not yet assured by any future date. For example, it appears necessary to scale present experiments up to larger machines in order to maintain an effective program. While these next generation devices are being conservatively designed, they are still experimental. In addition, even though the science may scale to larger sizes, technological, engineering and economic considerations may or may not permit exploitation of a given concept for practical fusion power.

This uncertainty has two practical consequences. First, since no clear or complete path to fusion power now exists for any fusion concept, and since fusion is one of the few major long-term energy options, no fusion scheme should presently be abandoned unless it can be shown fairly convincingly to be unproductive. Second, in order to establish proper priorities in the face of this uncertainty, a more or less continual assessment of fusion concepts and prospects must be maintained; otherwise the program may evolve into either uncritical support of unfeasible concepts or unwarranted and premature concentration on a single concept.

QUESTIONS

1. What program does ERDA have to assess prospects for fusion and to readjust the program priorities?
2. What are ERDA's present views about the prospects for successful fusion via tokamak, magnetic mirrors, theta pinches?
3. Will ERDA be prepared in due course to request funding for "test reactors" for more than the one promising concept, or does it plan to weed the prospects down to only one before that time?
4. What is the present support for tokamak, mirror and theta pinches, laser fusion, and less-advertised schemes?
5. In the light of our past experience in building "big-machine" facilities, are the schedules realistic?
6. In view of the lack of assurance as to laboratory success, how does ERDA rate fusion as an option to either the breeder or solar energy'?

BACKGROUND

Wit hint he next century controlled fusion could provide the world with an abundant, essentially inexhaustible supply of energy with a manageable impact on the environment, but the scientific demonstration that controlled fusion can provide an economical source of power is expected to require a series of large and costly devices.

The successful development of commercial electric power by controlled fusion requires the solution of extremely difficult scientific and engineering problems. In the magnetic confinement concept, the principal scientific problems concern confining and heating a deuterium and tritium plasma to reach conditions of net energy release, There are several potential difficulties which may limit the ability to achieve a stable configuration of the plasma and to effectively supply energy to bring the plasma to thermonuclear temperatures. Many of these problems have been identified on the present generation of experimental devices,

Among the magnetic systems which have been studied experimentally over the past 2 decades, the tokamak concept has been the most successful, Because of this, the ERDA fusion plan is based primarily on rapidly developing this approach. The program calls for scaling up the tokamak device in a series of progressively larger machines leading to the construction of an experimental device which can demonstrate that significant energy can be produced by controlled fusion. The latter device, the Tokamak Fusion Test Reactor (TFTR), is projected to cost $215 million.

Although tokamaks have not displayed any behavior which would definitely preclude successful fusion power reactors, there is still uncertainty as to whether these devices can be scaled up to the required size and power generation conditions. There is considerable feeling, however, that larger machines are considered in light of the need to keep several options open for development of controlled fusion. The major difficulties will arise when deciding how to proceed beyond the TFTR stage, to the Experimental Power Reactor (EPR) phase. The ERDA fusion plan is pursuing two other lower priority magnetic confinement schemes besides the tokamak, and it is not reasonable to assume that a separate EPR could or should be financed for all three. This is to say nothing, of course, of other concepts which may develop as a result of unforeseen breakthroughs. Therefore, ERDA must take extreme care in the coming few years to ensure that they have not abandoned other paths to controlled fusion prior to a complete evaluation of their potential.

18. Technologies for Fusion

ISSUE

New technologies, which will be critical to fusion's successful development through the 1980's, requires a long time to develop and will require rapidly increasing effort with time.

SUMMARY

Many critical technological problems relate to more than one fusion concept. Some typical critical areas where much work needs to be done are:

(a) Materials and material combinations resistant to high energy neutron bombardment from the fusion reaction.

(b) Economical storage of large amounts of electrical energy to operate pulsed fusion devices.

(c) Very large superconducting magnetic systems needed for all but laser fusion schemes.

(d) Diffusion of tritium fuel into and out of reactor materials.

QUESTIONS

1. How are energy storage requirements likely to affect the range of fusion concepts that can be developed?

2. How do requirements for new materials compare with previous programs, such as fission reactor development and rocket propulsion?

BACKGROUND

Present materials with high-temperature strength need to be perhaps 10 times as resistant to radiation damage by high-energy neutrons for use in a fusion reactor. Experience shows that new exotic materials require many years to bring to the application stage, even when substantial development funds and intellectual effort are applied; 10 to 20 years is not uncommon. The long time is required not only because the basic metallurgical research depends on new ideas, but because tests may require several years under simulated operating conditions. Fission reactor technology will not provide much support, because fusion requirements are more severe.

The energy storage devices are large by electrical standards (10 to 100 megajoules), but small by chemical standards (1/2 to 5 pounds of gasoline). However, the output is required rapidly in electric form, so conventional storage schemes do not suffice: capacitors are too expensive except in a few critical applications; superconducting magnetic energy storage is untried, and means of coupling out the energy are presently unsatisfactory; and rotating machinery is generally slow. This energy storage problem may limit the options for fusion, and the limits are uncertain.

The problem of large superconducting magnetic systems can be well illustrated by considering a conceptual design for a large tokamak reactor. It may have a magnetic field of *100,000* gauss *(10* tesla), in a doughnut-shaped device whose outer diameter will be at least 15 meters. This is like a subway tunnel made into a tight loop; the force from the magnetic field is about *6,000* pounds per square inch, 3 times that in present pressurized water reactor pressure vessels. Furthermore, this huge doughnut has inlet and outlet pipes which also give magnetic perturbations that increase the local stress. All this stress must be carried by reinforcing material at superconducting temperatures (perhaps 4 degrees above absolute zero) where most materials are brittle, not ductile. Practical structures in this size and magnetic field range will require years to develop, and the cost cannot yet be estimated.

Tritium, and deuterium and lithium are the fusion fuels for the first generation of reactors. The tritium must all be generated by interaction of high energy (14 MeV) neutrons in a surrounding breeding blanket of lithium, which would be about 1 meter thick. For each fusion reaction, one hopes to generate about 1.25 new tritium atoms (a fusion reactor is in this sense a breeder). But of the fusion fuel put into the reactor, only a small fraction, perhaps 5 percent, is expected to react per pass, while the rest escapes via an “exhaust” (yet to be realistically designed for any fusion concept) where it must be captured and returned to fuel storage with virtually no loss.

A major difficulty is that tritium is a hydrogen isotope, and like ordinary hydrogen diffuses very readily into and through materials, gets trapped in the metallurgical structure (grain boundaries), and is difficult to recover.

Chapter IV

Solar, Geothermal, and Advanced Technologies Task Group Analysis

A. SOLAR, GEOTHERMAL, AND ADVANCED SYSTEMS TASK GROUP

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B. SOLAR, GEOTHERMAL, AND ADVANCED SYSTEMS TASK GROUP ISSUES LIST

Decision-point criteria defining measures for evaluating success within a given solar energy program, choices among programs, and readiness for commercialization need to be estaiblished, quantified, and justified.

It is important that effective mechanisms be developed by which ERDA can make rational decisions on solar energy projects having great potential as future energy sources, but involing large cost outlays, and being subject to major uncertainties in projected costs and/ or technologies.

The ERDA Plan lacks adequate emphasis on the role that critical resources play in selecting energy alternatives.

A major concern with ERDA's research effort is that the management distinction between basic and supporting research formerly used in the AEC continues to polarize the sciences from engineering.

The use of outside organizations and Federal laboratories by ERDA for some of its program management functions, particularly in the solar area, could produce an ineffective organization.

The study of the decentralized production of Electricity has received 1imited attention, especia11y as it involves the potentia1 utilization of waste heat.

The program goals of the ERDA Plan appear to emphasize development of electric power systems to the point where the fu1l potentia1 of solar heating is not recognized and the possibility of obtaining synthetic fuels from solar energy is 1argely ignored,

The importance of solar heating and cooling relative to other programs is not recognized in the ERDA Plan.

The size, scope, and purposes of the solar heating and cooling demonstration program need specific definition.

A well-structured user incentive program would accelerate the solar heating and cooling of buildings (SHACOB) and accelerate dcvelopment of the infrastructure to support large-scale applications.

11. **Standards for the Measurement of Solar Heating and Cooling Equipment Performance 152**

For consumer protection, standards are needed to provide comparative performance ratings, to allow comparison of durabilitity, and assure proper installation of solar equipment.

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Onsite solar energy sources (most immediately solar heating and cooling), unlcss developed properly, will cause a significant utility peak demand problem,

13. **Biomass Energy and Food 155**

Biomass energy generation may conflict with food production.

14. **Legal and Institutional Constraints in Geothermal Energy 157**

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15. **Environmental Constraints on Geothermal Energy Development 159**

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16. **Nonelectric Uses of Geothermal Energy and Geothermal Goals ..161**

The ability to approach ERDA's presently unrea1istic **1985** goal for geothermal utiliza - tion will require a substantial increase in emphasis on nonelectric use.

17. **Variability y of Geothermal Reservoirs 163**

Each geothermal reservoir has its own unique character sties, which affect the rcsearch strategy and demonstration portion of the ERDA program.

C. INTRODUCTION

The review of ERDA's Plan for solar and geothermal technology is an attempt to examine the plan with as balanced a view as possible, in order to identify and summarize for the Congress those areas of the plan in which Congressional interest might be both appropriate and useful in the national interest. These areas are discussed in a series of issues, some of which cut across all aspects of geothermal, solar, and others which pertain to a specific technology.

There is unanimous appreciation of the problems and difficulties faced by ERDA in preparing the first National Plan for Energy, R, D&D in so short a timespan. In view of these difficulties, most observers feel that the plan is generally well done. There are important shortcomings, however, and it is hoped that the issues raised in this report will help the Congress and ERDA to refine the plan more effectively.

1. General Issues

In establishing a program that involves choices among several technologies of varying degrees of cost uncertainty, careful attention must be paid to the decision process to ensure not only that the most promising technologies are rapidly developed and commercialized, but also that marginal or high-risk technologies are not prematurely pushed into engineering development and demonstration phases (Issue Papers 1 and 2). Without these decision criteria much time, effort, and money can be wasted on unproductive projects.

A lack of adequate emphasis on resource assessment can lead to development of technologies which are counterproductive in that their use of other valuable resources (such as water, land, and materials) is excessive compared to the energy produced. The question of available manpower must also be considered in any resource assessment because of its potential for limiting program development (Issue Paper 3).

A final set of general issues deal with ERDA organization and program emphasis. If ERDA staffing is adequate, program management and assessment can be carried out centrally. This eliminates problems brought about by the multilayered management which occurs when out side organizations and/ or Federal laboratories are extensively used (Issue Paper 5). The separation between science, engineering, and marketing research which appears in the ERDA structure can reduce efficient flow from basic research to commercial application, This is critical when the nontechnical aspects of energy R, D&D are considered, but even more so for the development of high-risk technologies (Issue Paper 4), With regard to program emphasis, there is concern that ERDA has given inadequate attention to decentralized solar electric generation systems, Their ability to take advantage of the distributed nature of solar energy and to utilize waste heat is reason for giving them high priority (Issue Paper 6). Finally, a heavy emphasis on development of electric energy systems fails to address important possibilities for synthetic-fuel production and could preclude widespread direct use of solar and geothermal heat which may be more efficient both technically and economically (Issue Paper 7),

2. Solar Electric

Solar-generated electric energy is considered as one principal option for an inexhaustible energy source in the long term, Although no technical barriers exist which could preclude development of solar-generated electricity, the uncertain costs of these plants necessitate a careful development program if they are to be economically competitive. It appears that accurate full scale estimates, necessary for intelligent national energy planning, may only follow full scale prototype testing, regardless of whether these plants are themselves cost effective.

The large cost uncertainties of different solar electric concepts (ocean thermal energy conversion, solar satellite, solar thermal) necessitate development of precise decision criteria for alternative energy technologies (Issue Papers 1 and 2). Consideration of resource availability is critical due to the extensive use of land and, in some cases, water by solar electric systems (Issue Paper 3), Finally, the emphasis placed by ERDA on developing electric systems of all types, affects the priority placed on solar electric. If this emphasis is reconsidered, it could affect the rate at which solar electric is pursued (Issue Paper 7),

There should be a reassessment of the programs which call for pursuing four parallel efforts on a single concept—the central tower, Concern is also express that the ERDA approach to solar total energy systems may be too narrow in that photovoltaic systems were not included. Finally, there is the need to ensure that a full range of photovoltaic cell candidates is investigated (Commentary),

3. Solar Heating and Cooling of Buildings

Approximately 25 percent of the total energy used in the United States is for domestic water heating (4 percent) and for heating and cooling of buildings (2 I percent). In addition, approximately *29* percent of our total energy is used for industrial process steam and direct heat, Thus, in excess of 50 percent of total energy demand is the direct use of thermal energy. Solar energy is best suited to many of these direct thermal applications and it is in these areas that it can have its most immediate impact on our energy economy and can contribute substantially as a long-term, inexhaustible energy source,

The technology and economics for solar water and space heating are available now. Greater near-term emphasis should be placed in this area, relative to solar electric, along with acceleration of the Solar Heating and Cooling of Buildings (SHACOB) demonstration program. This is proposed as a more effective way to develop solar energy (Issue Papers 8 and 9). User and manufacturer incentives, as well as the educational and market development value of an effective demonstration program are necessary for effectively introducing solar heating and cooling into the economy (Issue Paper 10). Furthermore, to protect the consumer and maintain a high industry standard, it will be highly desirable to require manufacturers of solar equipment to provide valid performance information on their products (Issue Paper *11].* Although many of the legal and institutional issues will be resolved easily as the technology advances, some, such as guaranteeing access to sunlight, require attention now. Finally, as the solar energy industry develops, plans should be made to minimize the impact on-utility peak demand (Issue Paper 12).

4. Biomass

Synthetic fuel from biomass is considered by ERDA as a lower priority technology which could contribute in the long term, The uncertainty as to the economic and technological requirements for large-scale bioconversion systems makes premature any definite estimate as to the eventual contribution of biomass to the energy system, but support of genetic studies for the development of better energy crops is warranted. The potential conflict with food requirements for arable land is probably the most severe limitation on large-scale fuel production from biomass, Unless strategies can be developed to resolve both the perception and the fact of this competition, biomass energy will necessarily have limited impact (Issue Paper 13), Use of organic wastes, both urban and agricultural, offers another potential source of synthetic fuels from the bioconversion process, It is not clear to what extent ERDA has considered this, Finally, a careful assessment of the land availability and net energy gain per acre for marine biomass are needed for a sound decision on how to proceed with this technology (see Commentary, pages 165-167).

5. Geothermal

Geothermal energy is derived from the abundant thermal energy of the earth's core and usually is available for use as hot water or steam. "There is a substantial, but limited, number of individual geothermal reservoirs in which recovery of geothermal energy is deemed practical," Depending on the temperature and characteristics of the reservoir, geothermal fluids can be used for electric generation, industrial process heat, space heating, and air conditioning. Geothermal energy has a large mid- to long-term potential to contribute to the Nation's energy supply.

The main impediments to rapid utilization of geothermal resources are the legal and institutional constraints which could effectively prevent utilization of this resource (Issue Paper 14). The resolution of these legal and institutional problems is critical to the success of any geothermal energy development programs. Other potentially severe impediments relate to environmental considerations. Disposal of geothermal pollutants and avoidance of geological disturbances need to be given greater emphasis to ensure acceptable development of geothermal energy (Issue Paper 15).

An estimate of the exact rate at which geothermal energy sources will be developed is difficult to make and perhaps the ERDA near-term predictions are optimistic. Even though geothermal resources have the potential to meet the ERDA goals, they will probably not be achieved as soon as predicted unless there is a substantial increase in emphasis on nonelectric use. Since a major portion of the geothermal resources is low temperature, the most important use of geothermal energy in the United States may be for nonelectric uses as is presently the case throughout the world. The ERDA Plan may not assign enough significance to the development of the nonelectric uses of geothermal energy (Issue Paper 16). Each geothermal reservoir is unique in its characteristics, and, if the maximum amount of energy is to be extracted from any reservoir, the applications and the equipment technology must be optimum and must match the characteristics of the reservoir, Thus, the equipment and power conversion research strategy will have to be designed for a wide variety of possible utilization systems in order to minimize resource waste (Issue Paper 17).

D. SOLAR, GEOTHERMAL, AND ADVANCED SYSTEMS ISSUE PAPERS

1. Setting Criteria for Program Priorities

ISSUE

Decision-point criteria defining measures for evaluating success within a given solar energy program, choices among programs, and readiness for commercialization need to be established, quantified, and justified.

SUMMARY

The ERDA Plan does not treat the important question of how decisions will be made between solar energy technologies, and between solar and other energy options. Criteria are necessary to evaluate, for each program: (1) the projected rewards upon success, (2) the total costs to the public and private sectors, (3) the relative risks of economic or technical failure, and (4) the potential and projected readiness for commercialization. The decision-point criteria, to be applied at regular intervals in this process, must be predetermined by making a number of specific assumptions concerning the potential of all forms of energy generation, whether conventional or advanced. These assumptions need to be continuously evaluated and revised in the light of changing conditions during the course of the program.

QUESTIONS

1. What specific goals will be set (and when] against which to measure your solar and geothermal programs; that is, how will ERDA define success?
2. In the ERDA estimates of the penetration of solar and geothermal technologies into use by the private sector, what costs and cost relationships were assumed for capital, interest rate, discount rate, fuel, and operations and maintenance for the solar and geothermal systems and the conventional systems that they are to replace?
3. How does ERDA make evaluations of various energy technologies which may have to compete for limited developmental funds, such as solar electric and fusion?
4. Has ERDA conducted cost-benefit and risk analyses which might help implement the decisions to accelerate, abandon or delay available or near-term options, in the expectation that we can make it to the point where the more advanced technologies can adequately supply our needs?

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BACKGROUND

The lack of definitive program goals in the ERDA Plan can have two important consequences: It can distort projections of commercial acceptance of a technology, and it can increase the probability that an unsuccessful program will be drawn out longer than necessary. Criteria are needed to evaluate the relative rewards and costs of a research program in order to determine whether it should be continued, accelerated, or terminated,

Specific criteria, which may vary from project to project, are also needed in order to define the appropriate points at which paper studies move into component testing, component testing into pilot plant testing, pilot plant testing into demonstration projects; and demonstration projects into full commercialization.

An important criterion is the cost goal. For the different energy technologies treated in the ERDA planning documents these goals are represented by vague references to achieving economic viability (such as ocean thermal energy conversion), cost-cutting by given multiples where no present-day costs exist (solar thermal electric and wind), or specific cost goals in dollars per kilowatt (photovoltaics). Such goals have little meaning unless the assumptions and criteria that went into their formulation are available for comment by potential users. Furthermore, there is little indication that ERDA has conducted an analysis of the relative cost and performance risks, or of the costs associated with each of its programs in the light of future rewards of success.

2. Rationale for Funding of High-Risk Projects

ISSUE

It is important that effective mechanisms be developed by which ERDA can make rational decisions on solar energy projects having great potential as future energy sources, but involving large cost outlays, and being subject to major uncertainties in projected costs and/or technologies.

SUMMARY

The Energy Research and Development Administration is undertaking research and development of long-range solar energy projects which offer much promise in the future, but which, because they involve new and relatively unknown technology, suffer high levels of uncertainty,

Examples of such projects are the ocean thermal energy conversion and satellite solar power station programs in solar energy utilization. Although early-phase funding levels are not necessarily very large for these projects prior to reaching the demonstration phase, it is nevertheless very important that a rational method be established to decide: [a) whether or not to initiate the program (b) at which level to maintain or accelerate it, and (c) when to implement major and costly undertakings such as demonstration projects. There appears to be no effective mechanism now being used to make these decisions.

QUESTIONS

1. How does ERDA determine the relative funding levels for long-term, high-risk projects?
2. Does ERDA have a definite "plan" for continual review of these technologies and appropriate mechanisms to factor these analyses into its program plan?

BACKGROUND

Evaluation and decisionmaking on large projects which involve major uncertainties are currently performed by one of several methods, The most common is that where an in-house decision is made to proceed, requests for proposals on a "zerophase" study program are issued, and one or more contracts are granted to the winning bidder or bidders, In projects where some degree or prior experience is available, even though the system applications are new (such as photovoltaic converters or solar heating systems), it is possible for ERDA to obtain competent reviews of early studies and analyses and make reasonably accurate system performance and cost estimates, However, when the prior technology is in its very early stages, even if technical feasibility has been demonstrated, there is no obvious mechanism by which ERDA can test the conclusions of its study contractor. No matter how objective he may be, if there is little or no prior body of knowledge, the contractor's estimates are necessarily uncertain, performance estimates tend to be optimistic, and cost estimates are almost always too low. Hence, some method for evaluation involving both technology and cost uncertainty forecasting is necessary. At the very least, study results must be subjected to careful and extensive (probably contracted) review by other sectors of the field.

If uncertainties cannot be narrowed by such reviews, proceeding to costly demonstrations could be questionable. Premature demonstrations can have a far more severe effect than the simple wasting of funds, Often a project having great potential can be "turned off" by an unsuccessful demonstration; whereas a more measured approach, which allows a somewhat greater development of the basic technology for the project, might have led to success and subsequent benefits to society. However, it may be necessary to proceed to a demonstration even where the uncertainties remain excessive, simply because there is no other way to reduce them. This decision clearly can constitute a major gamble and should be reached only after the broadest possible interdisciplinary review.

An example of such a project which is currently under ERDA's jurisdiction is the ocean temperature energy conversion program. It has been subjected to "phase zero" studies, and its cost/benefit projections appear quite promising. However, there still remain major cost uncertainties (both capital and operating/maintenance) because of the lack of experience with the large-scale specialized equipment needed, biofouling, and corrosion in long-life metallic marine structures, and powerplant operations associated with offshore locations. Whether these uncertainties should be resolved by further studies and limited testing, or by an early demonstration project, is a difficult and vital decision, which probably is best approached (although not necessarily successfully) by extensive multisector review of study results.

A second example is the satellite solar power station, a concept which could offer significant long-range potential but does not appear anywhere in the plan, despite its identification by other Federal agencies as a highly promising future option. The decision processes needed to initiate the low-cost but essential early studies and experimental research efforts for such concepts apparently have not yet been properly formulated or implemented.

The Congress does retain the ability to critically review the decisions with which ERDA will be confronted in the future since all demonstration projects requiring funding in excess of a specified amount must be brought to the Congress for approval. Consequently, the Congress can ask the appropriate ERDA personnel at that time if the required cost-benefit-risk analyses have been made. Furthermore, the Congress can ask that independent reviews/assessments be made prior to proceeding with an authorization.

3. Resource Availability

ISSUE

The ERDA Plan lacks adequate emphasis on the role that critical resources play in selecting energy alternatives.

SUMMARY

The following major resources are likely to be affected by the various solar energy technologies:

„ . Water • Land • Materials • Energy
• Capital • Manpower • Air quality,

The ERDA Plan does not appear to have addressed adequately the problem of resource requirements of the various solar energy alternatives. It is essential that in our preoccupation with our current energy shortage we do not divert excessive amounts of our critical resources into energy production. Therefore, it is clear that integration of these impacts across disciplinary lines within ERDA will minimize the chance for oversight.

QUESTIONS

1. What steps is ERDA taking to evaluate, on a per-unit output of energy basis, the demands of their proposed energy alternatives on water, land, materials, energy, capital, manpower, and air quality?
2. How are the potential environmental impacts for the various energy alternatives being assessed?
3. What input/output (1/0] balances, including time-to-repay, have been or will be prepared for the energy and capital 1/0 of the alternative energy systems?
4. Are potential multiple uses of land and water being considered for the alternative energy systems?
5. What manpower projections, by category, have been made in connection with the Nation's total energy program?

BACKGROUND

In our last environmental crisis, the United States took several steps to improve air quality without adequate concern for our limited domestic supplies of certain types of energy resources. For example, the air pollution standards that mandated a switch from coal-burning to gas or oil-burning in some electric powerplants were established without an adequate apprecia- t ion of the limited national supplies of oil and gas. The switch back to coal now in progress represents a waste of energy, capital, and manpower. It is important that we not make similar mistakes in t-he future.

We are well aware of the limitations on available energy and capital. The potentially large demands on our supplies of other critical resources should be of equal concern. There are many competing demands for water which may well be the next critical factor in limiting our choices of life style. Opportunities for multiple use of water must be explored actively, and careful planning is needed to avoid exceeding safe consumption rates in any one region. Land use, also, must be assigned only after careful evaluations of all multiuse opportunities and priorities have been determined,

The reduction of engineering graduates in the last few years has placed us in a position where we cannot mount simultaneously an effective, large development effort on all new energy alternatives. Fortunately, a turnaround in enrollments has occurred; however, there will be a shortage of engineers and scientists skilled in solar energy technology for some years to come if other energy technologies are also expanded more rapidly. Fortunately, many energy technologies are supportive and many of the required personnel will be drawn from existing manufacturing concerns. A more serious problem may occur in the skilled trades required for installation and maintenance of the solar systems. The environmental impact of various solar energy sources and conversion systems is an important factor which must be considered. For example, atmospheric disturbance caused by local heating near large solar collectors could be significant as solar energy use increases.

Although the subject of materials is touched upon in the ERDA Plan, it has received inadequate attention. A case in point is in the collector part of the solar heating and cooling program, where the amounts of materials required to meet the projected energy contribution do not appear to have been considered.

The energy required to produce these and other materials must also be accounted for in the calculation of the net energy consumed to produce *1* Quad of output. For example, the production and fabrication of each ton of aluminum requires from *20,000* to *90,000* kWh of energy. Therefore, the 4.3 million tons of aluminum needed to ha; e an installed annual collection capacity of 1 Quad by 1985, requires from *0.35* Quad to nearly 1.5 Quads, Thus, the aluminum alone could cost as much as 7,5 percent of the energy produced over a 20-year equipment life. These figures emphasize the importance of programs to reduce the amounts of critical materials in collectors when large-scale implementation is contemplated,

4. Organization of ERDA's Research Program

ISSUE

A major concern with ERDA's research effort is that the management distinction between basic and supporting research formerly used in the AEC continues to polarize the sciences from engineering.

SUMMARY

It appears (ERDA-48, volume I, p. VIII-11) that the polarized research management policy is being carried over from the AEC into ERDA. The problem with this management policy is that its tendency to isolate scientific and engineering research has not produced innovative advances in technology comparable to those, for example, produced by the pacesetting electronics laboratories where a continuous spectrum of applied and fundamental research has been carried out under the cooperative leadership of scientists and engineers. Energy-oriented research is even more complex since it involves social and institutional problems in addition to the scientific and engineering aspects of advanced-hardware development. Thus, a nonpolarized institutional mechanism is needed if rapid solutions are to be found for these complex energy problems.

Creation of a Solar Energy Research Institute (SERI) represents one of several institutional mechanisms that can be utilized for this purpose, but there is as yet no indication that it will take the necessary interdisciplinary science/engineering form.

QUESTIONS

1. What are some of the specific programs of basic materials research that ERDA is supporting? How do they relate to ERDA's mid-term or long-term goals?

2. Is engineering work toward these goals being done in the same laboratory? If so, are the engineering and scientific programs monitored by the same ERDA manager? Do they have a common laboratory leader? If not, what mechanisms have been established to insure dialogue between the two managers as well as between the engineering and scientific efforts?

3. How is ERDA addressing the social, legal, and institutional problems associated with solar and geothermal energy?

4. How many dollars have been allocated to the ERDA laboratories for basic research in nonnuclear energy? How large a fraction of the total budget for such research does this represent? How many engineers and how many scientists are involved? Is this a typical program? Is ERDA supporting similar research at other institutions? If so, how are these programs coordinated?

5. Do you think SERI should be established as a central managerial and assessment office having regional technical laboratories? As a central research laboratory having regional demonstration projects? What function would ERDA like to see it exercise? What relationship does ERDA think it should have to existing facilities.

BACKGROUND

The distinction between basic and supporting research is motivated by the need to preserve scientific freedom in the research aimed at developing the conceptual context within which innovative technology operates. Experience has shown that those charged with engineering responsibilities and constrained by timetables are not effective managers of this type of research. However, experience has also shown that scientists do not generally apply their insights to the solution of practical problems if they are isolated from engineers and a participation in the mission orientation that engineering provides. Therefore, the optimum solution to innovation in advanced technology is cooperative leadership between scientists and engineers and other individuals and groups responsible for commercialization. Effective implementation of mid- and long-term programs in energy-oriented research requires a continuing dialogue not only between scientists and engineers, but also between design, materials development, materials processing, and system engineers, and marketing people. This dialogue can be effectively carried on within interdisciplinary teams sharing a common sense of responsibility. The following elements appear essential to successful advanced-technology development:

- A large measure of local management autonomy
- A definite, though broadly defined, mission
- Full-time, interdisciplinary technical 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
- A high degree of interaction with individuals responsible for commercialization
- Intelligence and strong personal motivation for performance at all levels of the organization.

Neither management practices nor funding decisions by ERDA have yet taken adequate advantage of existing organizations that have interdisciplinary capabilities.

5. ERDA Program Management

ISSUE

The use of outside organizations and Federal laboratories by ERDA for some of its program management functions, particularly in the solar area, could produce an ineffective organization.

SUMMARY

Interposing an additional management level in the development of solar energy technology is not likely to be efficient because some of the organizations used by ERDA for this function have not been constrained by cost considerations. Their management and contractual procedures are highly structural and extremely detailed, an approach which may not be appropriate—or cost effective—for the development of new solar energy forms.

Since the new energy technologies are very sensitive to costs, require innovation, and must interface with commercial energy producers (the utilities), ERDA's current reliance on outside management organizations may cause serious problems with program costs and the cost effectiveness of end-products.

Furthermore, when ERDA delegates complete control of an entire program or a large part of a program to one of these organizations, it may be too far removed from the actual research planning to maintain its mandated responsibility for the Nation's energy research and development.

QUESTIONS

1. What is the cost in time and money of interposing an additional management level in the energy development program?
2. Is a highly structured management style consistent with the goals of ERDA? What alternative management systems has ERDA investigated?
3. What portion of the ERDA budget is used to support program management and program planning by outside organizations and Federal laboratories?
4. What new responsibilities have the National laboratories undertaken in the last year? What staffing levels have these required? To what extent have the new staffing requirements been met by new hires? By internal reassignment?
5. What are the existing guidelines for number of contracts monitored by each program manager?

BACKGROUND

The rapid expansion of the Federal agency budget has forced ERDA to contract with organizations which have immediately available management capability. Their function is to provide an intermediate level of program management which has responsibility for the success of a large research area within which it selects, contracts for, and monitors specific research and development projects. In such a program, all communication with ERDA by individual researchers is through these intermediate agencies.

To a large extent, the past experience of these organizations has been in fields in which cost has not been a major constraint and in which highly structured crash programs have been frequent. Such approaches may not be appropriate for R&D programs which are aimed ultimately at commercialization.

6. Support for Study of Decentralized Solar Electrical Generation

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ISSUE

The study of the decentralized production of electricity has received limited attention, especially because it involves the potential utilization of waste heat.

SUMMARY

One chief advantage of solar energy is its relatively uniform distribution. Extensive electrical distribution systems are thereby rendered unnecessary, or at least can be appreciably smaller. The small distances between generator and user, which are possible with decentralized production, make utilization of the waste heat more feasible than with central station plants. Since future principal energy shortages are predicted mainly in the oil and gas supply areas, which have recently supplied the bulk of the country's thermal energy needs, there is added reason for extensive study of onsite production. The technology for solar onsite systems is at least as well in hand as central station technologies. Fossil-fired total energy systems are in use in many European countries. With photovoltaics especially there are no major economies of scale as larger electrical generating stations are contemplated.

The present ERDA organization establishes the study of decentralized electrical production as a small part of the central station solar thermal branch. A recent (and first) total energy symposium had almost no discussion of photovoltaic total energy systems, and very little on the problems of distributing the waste heat. The major issue of electric utility acceptance has received little attention.

The first major U.S. solar electrical system has recently been installed at Sandia, following an extensive survey under AEC sponsorship. No other electrical-generating facility will be ready for several years according to present ERDA plans, despite the relative simplicity of the technology and the availability of all components. The reason for this delay in construction is not clear.

QUESTIONS

1. Is present ERDA solar organization (which separates electrical and thermal areas) appropriate for undertaking a project which combines several technologies in a system?

z. What coordination is now occuring with the ERDA Conservation Division which is responsible for fossil-fired total energy systems?

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3. Why is no further immediate solar thermal hardware deployment planned, in light of the successful Sandia work, and the rapid cost improvements already obtained?

4. Why has the photovoltaic program not been more active in placing experimental total energy systems into the field (the only one is the very early "Solar One" at the University of Delaware, which was in large part funded locally)?

BACKGROUND

This topic is the subject of an extensive assessment by the Office of Technology Assessment which will be released at approximately the same time as this ERDA Plan review. Consequently, little more detail will be provided here, The interested reader is urged to contact OTA for the report from this additional solar energy assessment.

7. Emphasis on Electric Energy Systems

ISSUE

The program goals of the ERDA Plan appear to emphasize development of electric power systems to the point where the full potential of solar heating is not recognized, and the possibility of obtaining synthetic fuels from solar energy is largely ignored.

SUMMARY

Preoccupation with coal, solar, and nuclear energy for electric power generation has produced too narrow a view of the alternatives for utilization of our energy sources and, in selected areas, would commit the Nation—perhaps prematurely—to a massive change in the infrastructure for energy delivery and utilization, Much of the Nation's thermal end-use energy requirements over the long term may be met by those energy sources, particularly solar and geothermal, that are well suited to supplying thermal energy directly.

QUESTIONS

1. Since the production of heat from electricity is expensive and about half of the end-use energy consumption in the United States is in the form of heat, why hasn't more emphasis been placed on utilizing solar energy sources for direct thermal end-use requirements?

z. What are ERDA's plans for the development of technologies which produce synthetic fuels from solar and nuclear energies? How does ERDA's basic research program reflect these plans?

BACKGROUND

The ERDA Plan is apparently guided by the logic that: (a) because mid-term energy demands will be met increasingly by coal and nuclear energy (both best suited to electric power generation), (b) because maximum advantage is to be gained by having interchangeable energy sources, and (c) because electric power generation is the best "common denominator" for all sources (including geothermal, fusion, and solar), it is necessary to begin changing our infrastructure for energy conversion, delivery, and consumption to a massive dependence upon electrification. Thus, top priority in the ERDA Plan is given to systems that convert primary energy (coal, nuclear, solar, geothermal) to electricity. Lower priority is given to the direct utilization of thermal sources, whether from solar energy (a distributed source) or from geothermal and nuclear energy (centralized sources).

The use of biomass for fuel is regarded as a possible long-term energy supplement, but no explicit considerate ion is given to the production of alternative fuels, such as hydrogen, methane, and methanol. However, high-temperature electrolysis, photolysis, and pyrolysis for alternate-fuel product ion from solar or nuclear energy are attractive options awaiting technical development,

These priorities are not consistent with the present patterns of energy consumption. Approximately 25 percent of the present energy demand is for industrial process heating and direct heat. Moreover, about 25 percent of the energy demand will probably continue to be for transportation which is at present totally dependent on fossil fuels. There will be a continuing need for fuels for heating and cooling as a supplement to solar energy utilization systems.

8. Emphasis on Solar Heating and Cooling of Buildings

ISSUE

The importance of solar heating and cooling relative to other programs is not recognized in the ERDA Plan.

SUMMARY

There is abundant evidence that solar heating and cooling applications offer a larger potential for energy savings in the immediate and near term (to 1985), and beyond this to 2000, than any other solar applications, Indeed, ERDA's figures (ERDA-48, volume I, table 6-1) verify this statement; yet, solar heating and cooling is categorized at the third level of priorities as an "under-used mid-term technology" and one which may "provide an energy 'margin' in the event of R, D&D failure in other areas." These statements in the ERDA document project a significant potential for solar heating and cooling, yet underemphasize the development and actual impact of solar heating and cooling on our energy economy.

QUESTIONS

1. How does ERDA reconcile the inconsistencies between the statements made concerning priorities and emphasis on solar heating and cooling in ERDA-48 and the projected fuel savings shown in ERDA-48?

2. How does ERDA justify lower 1985 goals than those put forward by FEA in Project Independence as being attainable with an "accelerated government program?"

3. How does ERDA define the interface between solar "demonstration" and solar "commercialization"?

BACKGROUND

Solar water heaters are used extensively abroad (Israel, Japan, and Australia) and to a lesser extent in the United States (Florida and California). In excess of 100 solar space heating systems have been installed in the United States, most of which were not Federally funded. There is no similar foundation of existing technology in use to serve as a point of departure for other solar technologies,

The existing base for solar heating and cooling provides an opportunity for rapidly accelerating its growth through governmental action, including: (a) government-funded demonstration program intended to accelerate consumer acceptance; (b) more government-funded R&D to accelerate development of more efficient and lower cost systems; and (c) an incentive program, needed temporarily to enhance production and to bring down costs. The ERDA priorities in funding do not appear to recognize adequately this opportunity,

ERDA-48 (volume II, p. 40) projects energy saving objectives for solar heating and cooling at 0.2 to 0.6 Quad in 1985, The maximum objectives projected in 1985 for other individual solar technologies are small compared to the 0.2 to 0.6 Quad range projected for solar heating and cooling. Further, the 1985 goals may be too low. The accelerated program of FEA's Project Independence projects 1.5 to 2.0 Quads per year in 1985. Although the 2-Quad level may seem large, it is only 2 percent of anticipated total energy use projected by FEA in 1985 compared to almost 25 percent of total energy use for heating and cooling of buildings.

In view of the above, it seems reasonable to anticipate that ERDA would assign high priority to solar heating and cooling programs needed to capture this potential. The statements quoted in the Summary to ERDA-48 suggest otherwise.

9. Purposes of the Solar Heating and Cooling Demonstration Program

ISSUE

The size, scope, and purposes of the solar heating and cooling demonstration program need specific definition.

SUMMARY

The prime objective of the demonstration program should be to accelerate consumer acceptance of solar energy as a heat source so that substantial fuel savings can be achieved at a considerable earlier date than would otherwise result, The plans set forth in ERDA-48 do not appear to be oriented to achieve these purposes. In particular they do not appear to place as much emphasis on demonstration programs as (Public Law 93-409), The Solar Heating and Cooling Demonstration Act, does.

The manufacture and sale of solar energy systems for heating buildings and hot water has commenced on a small scale, while solar cooling is still in the development stage. Principal immediate emphasis in solar cooling should be research, development, and testing, whereas the thrust in the solar space and water heating effort should be demonstration.

QUESTIONS

1. Does ERDA agree that acceptable solar water and space heating systems are now commercially available?

2. Does ERDA agree that there is a disparity between the emphasis placed on demonstrat ion of solar heating and cooling in ERDA-48 and in (Public Law 93-409), the Solar Heating and Cooling Demonstration Act?

3. What should be the principal purpose of the demonstration program in the solar heating of buildings?

4. Is the suggested 400 solar-heated residential installations over a 4-year period sufficient for a vigorous demonstration program? If not, how many should there be?

5. Should solar-heating demonstrations be concentrated in the present year and next year, or should they be approximately evenly distributed over a 4- to 5-year period?

6. If solar heating is expected to grow in the private sector without government demonstration, is there justification for a demonstration program?

BACKGROUND

Commercially acceptable equipment for solar space and water heating is available in today's market and has already experienced limited sale in several sections of the country. The primary objective of the solar heating demonstration program is to stimulate a large increase in the rate of application of the technology and thereby a reduction in fuel consumption. By providing funds for a significant number of solar-heated buildings, ERDA's Plan could stimulate additional solar installations. The solar-heating demonstrate ion program is designed to show to the public at large (users; designers; builders; financiers; and tax, insurance, and regulatory authorities) the extent to which solar heating can be applied successfully and economically to a variety of buildings in wide areas of the country. Legal, institutional, environmental, and social deterrents to adoption should be assessed and dealt with as part of the demonstration.

Another purpose of the solar-heating demonstration program is the integration of various available components and subsystems into effective heating systems, and the determination of performance and cost of such systems, This program should demonstrate the benefits attainable by use of various subsystem and system improvements resulting from research and development.

The overall goal of the program should not be the development of technology or of hardware, but rather the development of consumer markets.

Research on and development of solar cooling and advanced solar-heating components and systems are important activities which should be conducted under a well-funded R&D effort, but this should be dissociated from the demonstration programs. Whenever such developments reach the stage at which available solar-heating systems have now reached, they should be included in the demonstration program as outlined above.

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10. Role of User Incentives in Solar Heating and Cooling of Buildings

ISSUE

A well-structured user incentive program would accelerate the solar heating and cooling of buildings (SHACOB) and accelerate development of the infrastructure to support large-scale applications.

SUMMARY

Properly structured user incentives are perceived as having the potential to substantially accelerate the growth of solar energy utilization. Although incentive programs should probably not be developed nor administered by ERDA, they have potential impact on ERDA's program. The important interfaces and distinctions between the various Federal agencies with regard to solar incentive responsibilities, have not been delineated in ERDA-48,

Incentives may be looked upon as temporary. Economics are less favorable for solar heating and cooling systems now than they will be in the long term because: (a) mass production savings in producing solar equipment have not yet been attained, (b) cost reduction engineering accompanying volume production remains to be done, and (c) it is probable that costs of competing fossil-based energy forms will be higher relative to solar in the near future.

However, there is a clear need for equitable treatment of the solar energy user. The individual user, turned energy producer, does not now receive the benefits of investment tax credits, depreciation allowances, depletion allowances, and other incentives provided to corporate producers of fossil energy forms. No incentive recognizes his contribution to society in reducing pollution, preserving fossil resources or reducing the Nation's dependence upon imported oil,

QUESTIONS

1. Why, as stated in ERDA-23, does ERDA propose to delay study of incentive programs until 1979?
2. What agency, or agencies, should develop a structured incentive program, and what should be the nature of ERDA's interaction with it?

BACKGROUND

The development of large-scale application of solar energy for the heating and cooling of buildings requires that a very large number of individual favorable decisions be made. In the majority of cases these decisions will be made by individual consumers, and a major factor in these decisions is the economics of the choice as perceived by the potential user, Each has his own perception of the relationship between first cost and annual savings required-to elicit a favorable decision, and the rate at which conventional energy costs will escalate, Thus, a properly structured incentive program which reduces the users first cost and operating cost will increase the number of individual favorable decisions. By subs id i zing equipment cost to the user, the cost savings effected by increased production can be made available to the consumer. On the basis of present equipment costs, the current payout time on solar systems, resulting from savings in conventional energy costs, is satisfactory to a significant but moderate number of consumers, mainly if the user's current alternative is electric energy. Because heating oil and gas prices are lower than electricity prices, for home heating, present costs of solar equipment currently represent an attractive investment only to a minority of consumers.

In a very real sense, the user of solar energy becomes an energy producer. His costs, which are largely investment related, must be competitive with those of producers of competitive forms of energy. Many of these are also capital-intensive. The corporate producer of competing energy is assisted in recovering his investment by investment tax credits which provide for immediate recovery of a portion of the investment from pretax income. Also, he can recover the balance of his fixed investment over time with pre-tax income through depreciation allowances. In addition, in some cases he also receives tax-free depletion allowances. If the solar energy producer is an individual homeowner, he receives none of these tax benefits, and must pay for his productive facilities with after-tax income, As an owner of commercial or rental property, he receives only depreciation allowances, Therefore, under present tax laws, the individual (noncorporate) producer of solar energy is subjected to discrimination and faces a disincentive to use solar energy.

11. Standards for the Measurement of Solar Heating and Cooling Equipment Performance

ISSUE

For consumer protection, standards are needed to provide comparative performance ratings, to allow comparison of durability, and assure proper installation of solar equipment.

SUMMARY

In order for the consumer or builder to intelligently compare solar equipment produced by competing manufacturers, it is necessary that all equipment be rated according to realistic and consistent standards. In order for the owner, builder, or architect to properly size equipment to the load, the equipment performance as determined from a standard measurement procedure must be specified. At present, many equipment manufacturers omit rating data or rate their own equipment in different terms so that it is very difficult to make comparisons or to size installations. Thus, it appears that standards are required not to protect the consumer. It is particularly appropriate that proposed incentive programs be tied to standards so as to discourage fraudulent or mistaken practices.

QUESTIONS

1. What are ERDA and/or other agencies doing to accelerate development of adequate standards?
2. Is it intended that standards be written so that they consciously avoid stifling innovation?
3. Will future standards be so written as to enable the consumer to make his own comparisons on life cycle cost effectiveness and energy conservation potential?

BACKGROUND

It is generally true in the development of an industry that some of those who enter it seek to capitalize on the consumer's lack of knowledge by marketing products which are either unsuitable for their intended purpose or which do not perform as claimed. Significant commercial sale of solar heating equipment is now emerging and volume will grow, particularly if sales are stimulated by the government through demonstration programs and user incentives. There is evidence that unscrupulous suppliers have already entered the market.

For the consumer to intelligently compare the solar equipment of different manufacturers, realistic and consistent ratings are necessary. To select equipment for a particular application, valid performance data are also required. At present, the performance of much equipment is unspecified or is presented in a manner unique to the particular manufacturer, and it is difficult to make comparisons or to size installations, This is true even of manufacturers whose reputation is such that there is no serious question of fraudulent claims. There are others whose performance claims are at least suspect.

Standards intended to establish equipment durability and life are also required to protect the user's investment, Although manufacturers' warranties are important, they are not a substitute for standards at this stage in industry development. Many equipment producers do not have the financial strength required to back up meaningful warranties, and therefore valid equipment ratings are essential.

Standards intended to assure adequate installation practices are also needed in lieu of nonexistent local codes and regulations. It should be expected that in time, such standards will be replaced by local codes and regulations.

It appears that the industry is still in a formative stage of development and that Government assistance is required to accelerate development of standards, It is paramount to rapid consumer acceptance of solar energy that the credibility of this industry be guaranteed by industry self-regulation and government vigilance.

12. Impact of Solar Energy on Utility Peak Demand

ISSUE

Onsite solar energy sources (most immediately solar heating and cooling), unless developed properly, will cause a significant utility peak demand problem.

SUMMARY

The economics of solar heating and cooling show that much of a building's energy requirements can be met by solar energy, The remainder must be supplied from an auxiliary source—for example, electricity or natural gas from a public utility or a stored onsite source, such as fuel oil. As the use of solar energy becomes more extensive, it may contribute to an increased peak demand problem for the utilities (particularly the electric utilities), because such energy supply systems could need auxiliary power simultaneously. Expensive standby electricity rates for solar energy uses could result, If auxiliary energy is supplied by a public utility, the solar energy systems should be carefully designed to minimize regional standby capacity. An alternative is onsite, self contained auxiliary energy storage (such as fuel oil], which makes the consumer independent of the utility or which will ensure his utilization of auxiliary sources at offpeak times.

QUESTIONS

1. At what levels of implementation (percentage of solar homes) will a peak demand problem for utilities become serious?
2. What standby energy and/or capacity (peak or off peak) rate structuring can be anticipated or recommended in the future for buildings using onsite solar energy?
3. What methods appear attractive for self-contained onsite supplementary energy storage?
4. How best can an onsite solar energy system be designed to minimize the impact on the utility system while simultaneously maximizing the benefit to the solar consumer?
5. What coordination is planned with the Conservation Division of ERDA for storage schemes uniquely applicable to solar systems?

BACKGROUND

At present, solar energy represents a negligible contribution to any region's energy economy and therefore has little effect on a utility's load distribution. As onsite solar energy use makes a greater impact, it in itself will cause an increasing peak demand problem for utilities unless these systems are designed wisely. If the utility standby capacity is used, then the solar energy system should be designed to demand supplementary energy at off peak hours and store it until needed, thereby minimizing the peak demand problem and possibly even enhancing the relation between peak and baseload for the utility. Another option is onsite, self-contained auxiliary energy storage (such as fuel oil, replenished as needed). This makes the user independent of a utility, but provides a long-term demand for onsite fuel (fuel oil). The extent and seriousness of this problem should be studied by FEA in conjunction with the utility industry, FPC, and citizen energy groups.

13. Biomass Energy and Food

ISSUE

Biomass energy generation may conflict with food production.

SUMMARY

In a world in which hunger is an ever-present concern, the use of arable land in the U.S. explicitly for energy production may be seen as irresponsible and may conflict with out own capacity to produce food. For this reason, it is important that the biomass program should not have an adverse effect on the production of food, either in fact or perception.

A variety of development strategies are available to satisfy this requirement, including:

- Improved plant genetics to emphasize biomass production with low water and fertilizer demands
- Changes in cattle-feeding methods and a reduction in the United States demand for beef
- Development of lands unsuitable for food crops
- Integrated food and energy production systems.

Unless such approaches are successful (and are also perceived as being successful), a large-scale biomass energy program will probably be unacceptable.

QUESTIONS

1. Have studies been made of the comparable economic value of organic materials when used for food, lumber, and energy?
2. What support is ERDA giving to genetic studies for the improvement or development of plants with high energy yield—and with low water and nutrient demands?
3. Is ERDA undertaking studies or research to ensure the long-term productivity of land used for intensive agriculture or tree-farming?

BACKGROUND

Biomass energy production has a number of attractive features. Aside from being environmentally benign, the organic products may be burned for energy or converted to liquid, gaseous, and solid fuel forms, They may be used for either peak- or baseload electric-generating capacity in central power systems, or may be used as transportable fuels.

This flexibility y of end-use extends to construct ion (lumber), food (cellulose), and the farms themselves (green belts and recreation), The specific way in which the organic farm product is used will depend on need and economics rather than on rhetorical choices between food and energy. Food and biomass energy are not mutually exclusive, and such implications may foreclose an attractive option, unless viable development strategies are pursued which do not seriously affect food production,

In addition the relatively low conversion efficiencies may mean that single-purpose energy plantations are not economically competitive. Energy biomass as a by-product from food production, however, may be economically a t tract iv e. Reorientation is needed in agricultural R&D to maximize food/energy production cost effectiveness,

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14. Legal and Institutional Constraints in Geothermal Energy

ISSUE

Geothermal energy implementation is not so much constrained by technology as by legal and institutional restraints.

SUMMARY

Federal, State, and local agencies are inexperienced and inconsistent in dealing wit h leasing, exploration permits, and licensing of geothermal resources. For example, geothermal resources are variously classified as water, minerals, or fossil fuels by regulatory agencies. Furthermore, unlike oil and gas exploration, extensive licensing and environmental analyses are required prior to exploratory drilling,

ERDA sponsorship of innovative legal and institutional studies may determine the best methods of resolving these and similar problems to ensure the orderly development of the resource.

QUESTIONS

1. What can ERDA do to expedite the leasing and exploration of potential geothermal resources?
2. Can the Environmental Impact Statement (EIS) requirements be modified to stimulate exploration without damage to the environment?
3. What steps can be taken to ensure the efficient development of the total geothermal resource ?

BACKGROUND

Current exploration for and development of geothermal reservoirs is being slowed by problems with the licensing, permitting, and leasing process. The present pace and requirements of the Bureau of Land Management's (BLM) procedures for leasing Federal lands, which con t a in much of the Nation's resources, hinder exploration. Experience shows that leasing without exploration will not encourage the resource industries to expand the data base required for valid resource evaluation.

Requirements for a complete Environmental Impact Statement prior to exploratory drilling may be an unnecessary burden. A complete EIS is not required for exploratory oil and gas drilling. Perhaps a better plan would be to allow exploratory activities to be initiated with limited initial environmental analysis, but subject to minimum standards. Upon discovery and con firmat ion of a resource, a master plan, including a complete EIS, would then be filed for approval before development of the field, The various states with geothermal resources define the material in different ways—that is, as water, as a mineral, as a fossil fuel, or not at all—and no ownership is defined for the dissolved minerals and gases, These ownership quest ions can only hinder development, since the problems of leasing large areas with multiple ownership of water and mineral rights are sufficient in themselves to prevent utilization of the resource, To encourage geothermal development, the resource will have to be uniformly defined as water, as a mineral, or as a unique resource. It may be in the interest of rapid utilization to cons icier innovative solutions, such as defining geothermal fluids and all associated minerals, gases (methane, carbon dioxide, etc.), and thermal energy, as a unique resource. Furthermore, to conserve the available resources, it may be necessary in some cases to consider legislation which would prevent exploit a t ion of the resource solely for the recovery of the mineral or methane content while wasting the thermal energy (heat) which is also available. A situation could develop similar to the one which existed when it was considered uneconomical to recover natural gas and it was wasted (flared),

Jurisdiction of regulatory agencies often overlaps and, in many cases, results in conflicts which can almost totally prevent utilization of the resource. An elimination of multiple permits for the same steps and unnecessary multitiered regulation may be one approach to the solution of this problem.

The use of water from geothermal reservoirs presents similar problems. In most cases, it will be necessary to reinject the spent fluids into either the reservoir or some adjacent geological formation to prevent subsidence and to dispose of any undesirable fluids. In some cases, water usable for irrigation must be wasted because current regulation may prevent its use simply because the composition of the geothermal fluid is different than that of the underlying fresh water aquifiers. Such restraints may be unnecessary in many areas,

15. Environmental Constraints on Geothermal Energy Development

ISSUE

Environmental problems, which have been inadequately stressed by ERDA, can place constraints on the potential development of geothermal energy resources.

SUMMARY

Geothermal energy development will have environmental constraints because of the disposal of gaseous and liquid pollutants, the potential for large-scale subsidence, and the potential for fault movement and earthquake generation. The implementation document of ERDA's Energy Plan does not adequately define the necessary environmental evaluation problem for geothermal development.

QUESTIONS

1. To what extent is land subsidence a potential problem with geothermal energy development, and how large a geographical area will be affected?

z. What types and degrees of exhaust gas treatment will be required to minimize potential air pollutant emissions from geothermal energy development, and what will be the resultant costs?

3. What chemicals can be economically recovered from geothermal brine streams prior to reinfection, and what additional effluent treatment may be required for above-ground disposal?

4. What magnitudes of earthquake intensities may occur from varying levels of geothermal energy development, and how might this constraint affect future utilization?

BACKGROUND

Geothermal energy results from the heating of ground water in the Earth's crust by proximity to its molten core, The four basic types of geothermal energy developments are the hydrothermal brine, geopressurized water, geothermal steam, and molten magma systems. Potential environmental impacts from major producing fields and potential major fields are as follows:

- The Geysers, California. Geothermal steam production for electric-power generation at the Geysers releases hydrogen sulfide to the atmosphere in small quantities with the noncondensable gases, whereas the major portions are precipitated as a sulfide sludge to constitute a potential solid waste problem. Mercury vapor is also released in trace quantities from the exhaust gases from the geothermal steam fields.
- Imperial Valley, California. Hydrothermal brine development in the Imperial Valley necessitates the disposal of highly saline brine streams through either deepwell reinjection or surface disposal. The potential for land subsidence and the activation of earthquakes are environmental constraints that can deter future development. The release of hydrogen sulfide in significant quantities constitutes a potential odor problem, while trace element releases of arsenic, boron, and

mercury also pose possibl e environmental problems.

- Gulf Coast, Texas, The geopressurized-geothermal water sources along the Gulf Coasts of Texas and Louisiana pose problems, relating to water quality, land subsidence, fault activation, and air pollution, but also provide for potential natural gas recovery, This energy source is still in the developmental stage where technical and economic feasibility has not yet been fully established. There is an additional need to provide for a detailed environmental assessment of this energy resource.

16. Nonelectric Uses of Geothermal Energy and Geothermal Goals

ISSUE

The ability to approach ERDA's presently unrealistic 1985 goal for geothermal utilization will require a substantial increase in emphasis on nonelectric use.

SUMMARY

A realistic maximum prediction for electric generation by 1985 is 4,000 Megawatts of Electric Power (MWe). To reach the objective of 10,000 to 15,000 Megawatts (MW) stated by ERDA, however, will require a large amount of nonelectrical uses. Since a significant portion of the resource base is low temperature, the most important use of geothermal resources in the United States may be for nonelectric applications. Indeed, the principal impact of geothermal resources on worldwide energy needs, to date, has been through nonelectric utilization.

The thermal energy from a geothermal reservoir can be used to replace electricity or fossil fuels in low-grade industrial heat applications and space heating. Geothermal water, because of its temperature, can also be used for solution mining, agricultural enhancement, and mariculture.

Of additional consideration in reaching the ERDA goal is the development of the number of wells needed for production and reinfection of 10,000 MW of geothermal fluids. This will require a significant fraction of the drilling rigs, material, and manpower presently being used for oil and gas exploration.

The ERDA Plan may not have assigned enough significance to the potentially important nonelectric uses of geothermal energy, By doing so, ERDA could much more realistically expect to reach their 1985 goals of geothermal utilization.

QUESTIONS

1. What portion of the 10,000 to 15,000 MW of geothermal energy projected by ERDA for 1985 is expected to come from nonelectric uses?
2. Is a process heat survey being planned to determine what fraction of the total industrial heat could be supplied by geothermal sources?
3. Would a person or firm who was interested in using geothermal process heat be eligible for the Federal Geothermal Loan Guarantee Program?
4. Does ERDA feel that as part of its dissemination and implementation function it should encourage the location or relocation of industries using low-grade heat near geothermal resources? Would the loan program apply?
5. Does ERDA plan to use geothermal resources to develop central systems for the space heating and cooling of buildings in populated areas?

BACKGROUND

A problem in interpretation of the ERDA document arises since it does not specify what fraction of the total utilization is, to be electric.

By 1985, the Geyser's vapor-dominated geothermal field may be producing l,550 MWe. The moderate temperature, low salinity hydrothermal demonstration plants (100 MWe total capacity] will not be operational until 1979-82. Pilot plant programs to test other geothermal sources are not scheduled to be operational until 1978-80. When the time required to advance from operation of a pilot plant through completion of a significant number of commercial plants (greater than or equal to 50 MWe) is considered, it is difficult to conceive that over 4,000 MWe could be on line by 1985.

Where geothermal energy is available, however, it can readily be used to replace electric or fossil fuels as sources of heat, Much of the energy expended in this country is used to provide heat for industrial processes, space heating, and for processes which depend on a supply of moderate temperature fluids. These include control of chemical reactions in petrochemical and chemical plants, drying of agricultural products, processing of foods, paper production, and mineral extraction and purification. Geothermal water could be used for food production enhancement processes that use temperature control to generate maximum crop yield, such as field and greenhouse heating. Protein supplies could be expanded by algae growth in ponds heated year-round by geothermal sources.

Geothermal fluids may contain valuable minerals that are recoverable. In many cases, the thermal energy in the fluids is sufficient to effect this recovery.

These nonelectric uses of geothermal resources can expand the definition of a geothermal resource because a low-temperature reservoir, which is not usable for electric generation, can be used for some of these nonelectric applications. Note, however, that nonelectric uses will, in general, probably be site specific. The ERDA Plan includes a pilot plant to investigate "multiple nonelectric uses of thermal waters." It is difficult to determine whether or not multiple uses will be practical at a given geothermal reservoir. Support for "demonstrations" at different locations for different purposes may prove to be more desirable.

To achieve the goal of extensive nonelectric use, a greater emphasis is needed, especially in the area of dissemination of information and in the technology of conversion of existing industrial heat processes from fossil fuels to geothermal heat.

17. Variability of Geothermal Reservoirs

ISSUE

Each geothermal reservoir has its own unique characteristics, which affect the research strategy and demonstration portion of the ERDA program.

SUMMARY

Each geothermal reservoir has unique parameters, such as size, fluid characteristics, and location. Furthermore, the nature of its energy source (heat) requires that it be used at or near where it is found. Thus, the design of equipment and energy conversion technology must be tailored to the characteristics of the fluid in each reservoir; consequently, different power cycles may be used. If the ERDA pilot/demonstration program were to concentrate on a single type of power cycle, multiple demonstrations of the same cycle would not aid the expansion and use of this resource. Furthermore, the most useful cycle for a given reservoir may be determined by the availability of cooling water near the well site. Thus, the equipment and power conversion research strategy will have to consider a wide variety of possible utilization systems to ensure high efficiency.

QUESTIONS

1. What cycles has ERDA identified for its pilot/demonstration program in geothermal energy?
2. How will advanced power cycles be demonstrated?
3. To what extent will the pilot/demonstration program be concerned with problems associated with integrating a geothermal source with an existing power grid?

BACKGROUND

The Energy Research and Development Administration has identified two moderate-temperature (about 200°C), low-sal inity reservoirs for demonstration and may choose the binary cycle (or a version thereof) for both of these reservoirs, A variety of canal: date power cycles are possible, but they have not been included in the current demonstration program.

The ERDA program also includes pilot power plants for a high-temperature, high-salinity reservoir, a geopressured reservoir, and a dry hot-rock reservoir. The best choice of power cycle for these pilot plants may be other than binary. Since most of the known high-tempera ure reservoirs are located in the South and Southwest where water is scarce the most appropriate cycle for a given reservoir should be determined by both the reservoir characteristics and the availability of cooling water.

The demonstration of power cycles will not solve all the potential operational problems associated with widespread utilization of geothermal energy for electricity. Dynamic control of the production/power/injection system is important, particularly if the electric load is lost, Any interruption of electric load on the generator creates control problems for the well since the fluid must bypass the power conversion equipment until load is returned to the system. With a steam geothermal reservoir, it is safe and environmentally acceptable to vent the steam. However, with saline hot water systems, the fluid can not be dumped because of environmental considerate ions. Thus, an artificial load (storage system) might have to be applied or the hot fluids would have to bypass the power conversion equipment and be immediately rein- jected. All of these control, grid interaction, and switching problems need to be considered when optimizing a geothermal electric installation,

E. COMMENTARY ON ERDA PLAN

This sect ion is devoted to several comments or short issue statements concerning the ERDA solar and geothermal programs. The nature of the issues addressed by these comments is such that a short exposition is all that is required to adequately express them. They should not be considered to be less important than the several issues developed in length in Section D.

1. Has proper attention been given to the necessary intraagency coordination mechanisms to ensure the cross-fertilization of information and technology between solar programs and necessary auxiliary efforts in other divisions?

   There are many aspects of the ERDA program which cut across divisional boundaries, and which, although assigned to one division, are of vital concern to the solar-geothermal programs. Examples of such areas are:

   - Energy storage
   - Hydrogen generation, distribution, storage, and utilization
   - Advanced power conversion cycles
   - Combined storage/conversion systems; e.g., fuel cells or thermal "batteries ."
   - Superconductivity y
   - Electric power conditioning (e.g., d.c, to a.c, conversion)
   - Resource availability, particularly fresh water.

2. Which research programs in the solar and geothermal areas are budget limited? If more funds were provided, what would be done with them, and how would they assist the research effort?

3. What are the differences between a test bed facility, a pilot plant, and a demonstration plant?

   In ERDA language, a test bed is a facility used to test components of and ideas for a total system. A pilot plant is a complete system assembled t() show technical feasibility and to gain construction and operating experience. A demonstrate ion plant is a near commercial scale facility used to show economic feasibility y although the plant itself may not be economically competitive at that time. Another but totally different concept of "demonstrations" is illustrated in connection with solar heating and cooling of buildings (see Issue Paper 9), where the objectives are to generate a user market.

4. Does ERDA's patent policy enhance or impede development and application of solar and/or geothermal energy?

5. Should ERDA research funding include requirements that access to background proprietary information and patent positions be granted to the Federal Government?

6. How does withholding of "proprietary information" by industry affect ERDA's state-of-the-art reviews and data-bank usefulness'?

7. What should be the nature of incentives to use windpower systems and geothermal heating systems?

   The issue of incentives related to solar heating and cooling has been discussed previously (see Issue Paper 10). Many of the same points also apply to wind power and geothermal heat utilization,

8. Would it be appropriate for ERDA to fund traineeships in solar and geothermal technology?

   The discipline requirements for the utilization of these resources is such that some incentive, similar to the former NASA traineeships, may be required to encourage pursuit of these specialized educational backgrounds. The need for these hybrid scientists/engineers is immediate,

9. What is the reason for the apparent emphasis on the central tower solar electric concept to the exclusion of solar electric approaches?

10. Should the Plan make a specific commitment of allocating a portion of the solar heating and cooling demonstration projects to the retrofitting of existing residential and commercial buildings?

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Although solar heating and cooling systems will be more cost effective in new buildings designed with the systems, the approximately 65 million existing buildings present an immense potential for solar heating and cooling, with a subsequent significant potential fuel savings. This is particularly true in the case of solar-heated domestic water.

11. What is the status of the Guaranteed Geothermal Loan Program?

The Geothermal Guaranteed Loan Program will be impossible to implement without appropriate ions available to back up the guarantee.

12. Why does a solar thermal total-energy system demonstration appear in the plan, but no photovoltaic total energy system?

Photovoltaics (at least onsite) would appear to be at least as well suited for total energy systems.

13. How does ERDA plan to verify and supplement the estimate of geothermal resources indicated in the USGS Assessment Program?

USGS cannot drill exploratory geothermal wells, but in order to determine the potential reserves, geothermal exploratory wells must be drilled. Such exploratory drilling will allow for better planning of resource utilization and determine the resource for which conservation technology should be developed.

14. Why is little emphasis placed on alternative solar-cell materials (other than silicon) considered in the ERDA Plan?

A number of other materials (such as gallium arsenide, cadmium sulfide, and iridium phosphide) are receiving considerable attention from the private sector, and some of them appear quite interesting.

15. Does the potential for the export of solar, wind, and geothermal technology and equipment have any impact on R&D strategies?

‘ 16. Will geothermal resources benefit only certain segments of the country?

Even though geothermal resources are regional in occurrence and nontransportable, this does not make it a regional resource which will benefit only a small segment of the population. Because of the nature of the resource (heat), it must be used near the well site. However, when geothermal energy is used in one portion of the country to replace fossil fuel heat sources, the fossil fuel saved is available to the country as a whole in the form of high value liquid fuel,

17. What is the role of ERDA in the development of geothermal exploration methods?

The development of advanced geophysical exploration techniques is needed to ensure full and rapid development of geothermal resources, If ERDA agrees that it is within the scope of their mandate to do this type of work, such a statement should be made with details provided.

18. Has ERDA given adequate attention to the use of international research efforts to solve common energy problems?

The solar energy field is a particularly attractive area for cooperation.

19. Why hasn’t the use of wind energy for nonelectric applications been considered; e.g., water-pumping, with pumped-storage capability?

It is possible that significant capital cost and energy savings might be realized by exploiting all possible avenues for these applications.

20. Has ERDA considered establishing test facilities, pilot plants, and demonstration plants on Federally controlled rather than privately controlled lands?

This approach, with the assistance of private industry, would allow the rapid testing of technology without many of the long delays associated with licensing and restraints on private land. This approach should be considered for cases where early testing of a resource or technology is mandatory.

21. What is the nature of ERDA’s interaction with the EPA program in urban waste disposal? How do you integrate the use of agricultural and forest wastes with your program of energy from biomass?

The use of’ organic wastes: urban, agricultural, and tree farming, can make a modest contribution to the fuel supply while reducing an adverse environmental problem.

22. What ocean areas have you identified that have suitable upwelling conditions for marine biomass cultivation? Is this area large enough to allow a significant impact? What is your estimate of the net energy-gain per acre of marine biomass and the cost to harvest?

Chapter **V**

Conservation Task Group Analysis

A. CONSERVATION TASK GROUP

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ERDA has formulated no plans or programs in the productive use of waste, although specifically directed to do so by Congress.

C. INTRODUCTION

ERDA's programs under the purview of the Assistant Administrator for Conservation are among the newest and least developed of any within the Agency, With the exception of the projects in the division of transportation which derived from the Alternative Automotive Power Systems (AAPS) program within EPA, the Division of Electrical Energy Systems in the Department of the Interior, and the Atomic Energy Commission's storage work, all areas had to be created and assembled in the past 6 months without benefit of antecedents. The staff responsible for this planning is to be credited for a successful beginning, but much further analysis and program development is still required. The effort of the staff is all the more noteworthy in view of an apparent lack of appreciation within the Government of the role that conservation can provide in helping to meet the Nation's energy goals. The far greater emphasis given to energy supplies in comparison to energy demands in the ERDA Plan has roots in the thinking which informed the national policy goal stated by ERDA as "to provide for future needs so that life styles remain a matter of choice and are not limited by unavailability of energy." This statement makes no mention of the total cost of the energy made available. It appears to focus on the necessity of supply at any price and does not acknowledge that life styles can be maintained and improved with more cost-effective use of energy. To provide a better balance between energy supply and demand, the goal might be better stated as "to provide the opportunity for present and future generations to enjoy those amenities which they deem worthy at minimal total cost to themselves and society."

The main issues upon which the conservation panel reached a consensus are summarized b y the following statements:

- **The ERDA Plan could advantageously take a more vigorous approach to energy conservation, both in its objectives and in its level of effort.**

The energy conservation targets presented in the ERDA Plan project only minimal gains over those which are already broadly recognized as attainable with existing technology, In part, this is due to the ERDA scenario which ignores price elasticity of demand.

The lack of an aggressive conservation program is also reflected in ERDA's budget requests, which allocate less than 2 percent of its total budget for conservation. The conservation program is too narrowly focused in the transportation and electrical sectors. These problems are addressed principally in Issue 1 and are a recurring theme in others.

- **ERDA'S plans for program management and coordination within the agency, with other Federal agencies, with State and local governments, and with foreign governments are not clearly delineated.**

Most of ERDA's conservation efforts will be highly complex, involving jurisdictional questions between programmatic divisions within the agency, and between various agencies of Federal, State, and local government. Use of foreign technology will require cooperative arrangements with other governments. For example, it is imperative to closely link Buildings to solar thermal utilization. The mechanisms for interaction must be resolved quickly to eliminate unnecessary duplication of effort and to assure that projects flow smoothly through the various governmental entities responsible for research, development, demonstration, assessment, and implementation. Issues 2 and 12 consider this problem in greater detail,

- **ERDA has not yet developed a comprehensive plan for interaction with the private sector.**

In energy conservation, interaction with the private sector is especially crucial, since the consumers of conservation technology are diverse and numerous.

Energy conservation is as much a matter of private enterprise interest as governmental concern. Many valuable innovations have been developed in the private sector. Many others can be developed and commercialized through Federal/private partnerships. Some programs reflect lack of knowledge of current industrial know-how. There can be no assurance that ERDA R, D&D results will be commercialized unless the corporate and individual consumers actively participate in the planning, execution, evaluation, and implementation of the research.

ERDA must make a serious commitment to establishing constructive relationships among Government, industry, and private citizens to ensure the success of its energy conservation efforts, Various aspects of this problem are treated in Issues 3 and i'.

• ERDA's use of the term "conservation" is too broad. As a result, the program plan for conservation is incomplete in some areas and overextensive in others.

ERDA's interpretation of the term "energy conservation" is important because it defines the boundaries of the conservation program. Its definition of the term is sufficiently broad that not only fuel shifts but even financial savings, can be rationalized as "conservation, " This is far different from the more generally accepted definition of conservation (saving energy in a cost-effective way). Irrespective of the importance of the various ERDA programs under "conservation, " there is a danger in their inclus ion as "energy conservation, " One consequence is a loss of focus on the role of the energy consumer in conservation, Another is the potential diversion of funding from true conservation projects to others better justified on grounds other than energy conservation, such as the ERDA electric energy systems program, The specifics of the problem are discussed in Issue 4.

. ERDA does not adequately address the social, political, economic, and environmental issues associated with implementation of both existing and new energy conservation technologies and systems.

Certain programs proposed by ERDA may ultimately be very successful technically, yet have no real impact on society because of inherent nontechnological problems. In the energy conservation sector, the task of implementation is made more difficult by the fact that the ultimate beneficiaries, consumers, are subject to a multitude of constraints,

A meaningful R, D&D program must consider these nontechnological barriers at the earliest stages of planning. This is done well in the programs for "Buildings" and "Industry", but in general the ERDA document is basically a technological plan, with little evidence of societal assessment in its proposed projects. Almost total attention is given to creation of technologies and not enough to analysis and evaluation of alternatives. ERDA is charged with this responsibility (Public Law 93-577 Sec. 5(a)); its plans and programs must consider these nontechnological factors, Issues 5 and 9 describe the implications of this problem in specific areas of concern,

. ERDA has not adequately established priorities within its conservation program or of the conservation program relative to energy supply programs.

Extensive data on energy usage have been collected within the past several years by Government and private researchers; improved methodologies have been developed for assessing the potential savings which might be realized by the implementation of various conservation innovations. With the exception of its program in the Building sector, it is not evident that ERDA has made effective use of existing quantitative tools and data in establishing priorities for the the conservation program, or that it has plans to develop improved assessment tools for use in future program planning and evaluation, Issue 6 addresses this problem in general terms, whereas Issues 10, 13, 15, and 17 consider priority questions in specific areas.

In addition, several topics which do not fall naturally into the general grouping of issues outlined above are discussed in the following papers: specific programs on demonstration and research on buildings (Issue 8); substitution of fuels in industry (Issue 11); electrical load management [Issue 14); and wastes (Issue 18).

D. CONSERVATION ISSUE PAPERS

1. Importance of Conservation

ISSUE

The ERDA Plan should better reflect the urgency and importance of conservation in responding to the national energy problem.

SUMMARY

ERDA-48 states that energy conservation is of "crucial" importance, particularly in the next decade. However, its program priorities and funding requests are inconsistent with the stated importance of conservation. There is little evidence that cost-effectiveness or environmental/economic impacts have been considered in establishing program priorities; moreover, programs to address nontechnological but none-the-less vital issues in developing and implementing conservation activities seem to be missing. A sense of urgency to achieve results (saved energy) seems wanting.

QUESTIONS

1. How does ERDA expect the importance and probable cost-effectiveness of conservation to be reflected in its programs, especially in comparison with supply technology programs?
2. What guidelines are used to decide whether an energy conservation activity should receive ERDA funding rather than funding from some other Federal agency or the private sector?
3. What is ERDA doing to ensure that its program can be rapidly implemented through an adequate, highly responsive procurement system?

BACKGROUND

Studies of ways to respond productively to the problem of energy price and scarcity conclude that most cost-effective options available to us relate to improved utilization rather than to accelerated supply growth. The ERDA enabling act, Public Law 93-577 Sec. 5(a), states that". . . energy conservation shall be a primary consideration in the design and implementation of the . . . program . . ." Opinions differ regarding the extent and rate at which price effects alone will induce "the market" to shift to more efficient energy use. Many observers feel that because of a variety of market imperfections and Government regulations in the energy area, the price response will be far less complete and less rapid than needed to meet national needs.

Most observers feel that the energy problem is so urgent for both economic and national security reasons, that an aggressive campaign must be mounted to:

- Accelerate the rate at which end-use efficiencies are improved;
- Extend improvements from those that have sufficiently fast payoff to attract private investment to those that self-amortize more slowly but are still attractive in terms of public benefit.

In addition, the public benefit of reduced vulnerability to embargoes and price cartels provides justification for Federal incentives that help induce otherwise "no profit" shifts to higher efficiency.

The urgency and cost-effectiveness of a major effort to improve energy utilization is recognized in the general pronouncements of the ERDA Program Plan, but a closer review shows that the pronouncements do not translate into actual program emphasis and budgetary priority:

- Despite the high priority and cost-effectiveness of conservation the proposed budgetary allocation to conservation versus supply development is only about 2 percent. Clearly the ERDA budget decisions accord little weight to relative cost-effectiveness.
- Approximately half of this 2 percent actually is only indirectly related to end-use conservation; rather, it pertains to miscellaneous programs (e.g., electric transmission and distribution) assigned to the Assistant Administrator for Conservation that, however worthy for other reasons, carry low priority in terms of conservation potential, per se.
- Many of ERDA's conservation programs are overly cautious and conservative (e.g., the electrical sector); they are not comprehensive (e.g., the transportation sector), they display little aggressiveness or sense of urgency as well as an unwillingness to make high-risk but promising, high-leverage investments.
- The old Atomic Energy Commission procurement procedures must be modified to match ERDA's new requirements, especially in the area of conservation. In this area, ERDA must deal with a very diverse set of constituents rather than with a small number of large industrial concerns. There is little evidence that these modifications are being made.

2. Program Management and Coordination

ISSUE

ERDA's plans for conservation program management and coordination within the agency, with other involved Federal agencies, with State and local governments, and with other nations need additional attention.

SUMMARY

ERDA has been mandated (Public Law 93-577) as the primary agency in energy R, D&D with responsibility y to integrate and coordinate national efforts. Its mission is to assure that existing ancillary resources (e.g., capital) manpower, materialist and expertise) are utilized to the maximum extent, thereby making available the most promising energy alternatives.

It is not evident in ERDA's plans whether a comprehensive framework is being established to permit ERDA to perform adequately its required coordination/integration role. Insufficient attention is given in the Plan to the implementation of formal mechanisms or operating relationships to assure:

- location of programs within ERDA to maximize chances for an integrated systems approach to solving problems;
- coordination of programs with the various Federal agencies, and State and local governments involved in energy conservation work; and
- integration of foreign energy conservation R, D&D into domestic planning.

Lack of programmatic elements to deal with the above responsibilities could seriously impede the effort to achieve the stated objectives within the conservation program.

QUESTIONS

1. As specific examples of problems in definition of responsibilities:
   - What is ERDA's role in the development and implementation of technologies to recover resources and the energy content of municipal garbage? This would appear to bean important function of ERDA and is so stated in the legislations, yet ERDA's budgetary commitment is of a token nature, and other Federal agencies are involved in this area.
   - How are the solar heating and cooling programs to be coordinated with the building conservation programs, since both are intimately related to building design?
   - Why is work in Electric Conversion, Electric Power Transmission and Distribution, and large-scale (powerplant) Energy Storage under the purview of the Assistant Administrator for Conservation?
2. What specific management mechanism, technique(s) or coordination controls will ERDA use to integrate and coordinate its conservation activities with other Federal agencies?
3. In the near term, where direct Government influence and incentives can create energy savings, how is the responsibility for energy conservation divided between ERDA and FEA?

4. How does one separate the policy implementation role of FEA's energy conservation program from the R, D&D activities of ERDA?

5. How does the ERDA Plan to integrate and coordinate its activities with State and local authorities assure that overlap, duplication, and inefficiency in ancillary resource utilization are avoided?

6. What provisions have been made in the ERDA Plan to assure that the agency will utilize, to the fullest possible extent, innovations for energy conservation developed in other countries? Who will be responsible for these cooperative arrangements?

BACKGROUND

ERDA has been mandated (Public Law 93-577) as the primary agency in energy R, D&D with responsibility for coordination and integration of national efforts and for cooperation with other nations. Programs to develop energy supplies have existed for many years. However, only in the recent past with the rise in energy prices and uncertainties in availability, have significant efforts been focused upon energy conservation. As a result, responsibility for energy savings programs is divided within ERDA, among other Federal agencies, and among State and local governments. Although there are varying perceptions about appropriate division of responsibility, there is general agreement that operating relationships must be established in order to coordinate ongoing efforts at all levels. It is not clear from the ERDA Plan that a comprehensive framework has been established which will permit ERDA to adequately perform its required coordination/integration role. These mechanisms need to be resolved early in ERDA's development.

Within ERDA itself, there are questions regarding the assignment of programmatic responsibilities, For example, on the one hand, responsibility for Solar Heating and Cooling of Buildings is located under a different ERDA Assistant Administrator than programs for minimizing energy required to operate buildings even though the two program areas are closely interrelated, More attention needs to be given to the location of programs within ERDA in order to maximize chances for an integrated systems approach to solving conservation problems,

In a similar vein, some means of formal management control must be developed to assure coordination of related programs in various Federal agencies and departments (e.g., the Federal Energy Administration, Environmental Protection Agency, Federal Power Commission, Department of Transportation, Department of Commerce, Housing and Urban Affairs Department, U.S. Department of Agriculture) that impact on energy demand. In many cases ERDA has a program goal that is either identical or implicitly related to some other agency area of concern. Of critical concern is the relationship between ERDA and the Federal Energy Administration in their 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 serious attention, An implementation strategy must be initiated at the earliest stage of research planning and setting of priorities and goals, It is encouraging to note that such coordination seems to be already operational in the Buildings and Industrial sectors,

Likewise, an effective link needs to be made between the Federal system and State and local authorities, since they are responsible for some of the most important policies regarding energy use, The integration of State and local activities into the overall process is important since such activities reflect various regional perspectives. It is also essential in providing an effective channel for information transfer and technical assistance to these groups.

Finally, an equally important consideration is the manner in which ERDA intends to participate in international cooperative R, D&D programs, It is important that the agency define more precisely how it will assure that foreign energy conservation work is integrated into domestic planning.

Although it is reasonable that energy conservat ion efforts are ongoing in more than one agency, i t is necessary that these efforts be complementary. The "lead agency" role is at best difficult, but without clearly defined management controls and effective leadership, the result wil1 be duplication and inefficient t use of public resources.

3. Interaction With the Private Sector

ISSUE

A comprehensive plan is needed for interaction between ERDA and the private sector in energy conservation.

SUMMARY

Without close coordination with industry and other private organizations, widespread implement at ion of research results cannot be attained. The problem is complex since various areas of the private sector are organized quite differently and each (e. g., encrgy consuming industry, energy producing industry, the Electric Power Research Institute (EPRI), individuals, public institutions], will require a unique approach to constructive interaction. The ERDA Plan provides few details as to how this interaction is to be accomplished,

QUESTIONS

1. What specific organizational structures has ERDA devised to obtain and utilize input from the industrial, labor and consumer sectors in its basic program planning effort?
2. By what mechanism are ERDA and EPRI program planning activities coordinated?
3. How does ERDA plan to collect, distribute, and implement both public and private conservation research results?
4. What are the criteria used for deciding whether, and to what extent, energy conservat ion activities should be supported with Federal funds?

BACKGROUND

In the area of energy conservation, close coordination between government and private organ i zations, such as industry, professional societies, anti consumer groups, is crucial. While governmcnt may initiate much of the research, u1timate implementation is largely dependent on the privatc sector.

The detailed mechanisms for interact ion will vary great1y from one industry to another, and will even vary somewhat within industries, For e x am ple, the building industry is highly fragmented, involving standards organizations, professional societies, manufacturers, trade groups, and labor organizations, each of which will have a different role to play in utilizing new conservation technology. Many components of this sector have no research capability of their own, and will depend heavily on government for hardware development and policy direction. Others have excellent research and development resources and can be vital contributors to the national program at the planning and development level. The detailed format for ERDA coordination with such diverse components of the private sector must be carefully designed to be effective,

The electric utilities industry is a special case, both because of its central role in energy conversion and distribution and because of its cooperative sponsorship of a wide variety of research and development projects through EPRI. Because of its close connection with the utilities industry and its industry advisory committees, EPRI is both aware of the problems of the industry and well-situated to lead in technology transfer, ERDA, on the other hand, should take the lead on projects with excessively low profit potential, high risk, or high capital requirement.

It is vital that ERDA take affirmative steps to involve all elements of the private sector in the earliest possible stages of program planning. Advisory boards with representatives from industry as well as private citizens can provide important viewpoints to aid in the decision-making process and to support alternative courses of action. Since many energy conservation initiatives may have significant impact on relative competitive positions within industry, government's role must be carefully defined.

Budgeting for research by ERDA should take account, wherever possible, of private expenditures for related efforts. Cooperative programs involving cost-sharing contracts must consider patent and proprietary rights. Even in the development and demonstration stages, ERDA must appreciate and work to eliminate problems that might impede the eventual commercialization of new processes and products,

4. Use of the Term "Conservation"

ISSUE

ERDA's operational definition of energy conservation is too broad.

SUMMARY

ERDA uses the term conservation so broadly hat almost any effort to improve efficiency or cost in either energy supply or energy demand can be subsumed with in it. This has the possible consequence of shifting the emphasis on responsibility for conservation actions away from the consumer toward the suppliers and distributors of energy.

As an example, the Electric Conversion, Energy Storage, and Power Transmission programs can produce large cost savings but, in most instances, their energy savings potential is small in comparison with efforts in the energy demand sector. As important as they are, these cost savings could distort the contribution of these programs in terms of the objective of reducing energy use. This could cause a shift away from end-use conservation priorities to those on the supply side within the overall conservation program. Also to increase their chance of success these programs should be coordinated with research on other components of the electric power system with which they are related synergistically.

QUESTIONS

1. What is ERDA's opera tional definition of conservation ?
2. How can ERDA better structure the diverse activities under its Assistant Administrator for Conservation in order to distinguish their goals more clearly?
3. What level of energy savings can be realized as a result of success in the proposed programs in electric conversion, electric transmission and distribution, and energy storage? How does this compare, in terms of cost, with savings achievable through load management ?
4. How does ERDA propose to integrate the various component programs of the electric power system?

BACKGROUND

The operational definition of conservation is of critical importance, particularly during the period in which the ERDA energy conservation program is being established. Conventional usage defines energy conservation as that array of technologies, techniques, and strategies which results in more "efficient" utilization of fuels to accomplish a given end. Another definition also includes lifestyle and institutional changes which result in a reduced demand for energy consumption.

ERDA's program plan includes the first of these definitions, i.e., more efficient means to achieve given ends, and in some areas, goes

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beyond the latter to include interfuel shifts and measures which might more correctly be termed "economic efficiency" rather than energy efficiency improvements. Too little attention is given, however, to efficiency increases in end-use. This results in an operational definition of energy conservation which permits the rationalization of virtually any efficiency change in the energy supply or demand systems as a conservation measure and can shift the emphasis on responsibility for conservation actions from the consumer to the producer of energy.

The program areas of Electric Conversion, Energy Storage, and Electric Power Transmission and Distribution are examples which meet the "economic efficiency" criteria and are not principally energy efficiency measures. Although these programs are quite worthwhile, there is a very real danger that by their inclusion under the generic term of conservation they could mask a low level of commitment to programs more directly focused on the important task of eliminating wasteful expenditures of energy.

In addition, these programs are principally concerned with various components of electric power systems and should be investigated in coordination with each other and with the other system components rather than as conservation measures. This, too, provides incentive for administrative relocation of these programs.

5. Need for Nontechnological Research

ISSUE

ERDA's role needs clearer definition with respect to research on nontechnological issues associated with energy conservation.

SUMMARY

present inefficient patterns of energy use, characterized by inefficiencies in buildings and consumer products, in transportation, in industrial processes, and in the generation and transmission of electricity, are to a large degree caused by a combination of historical, institutional, governmental, economic, and social forces. Implementation of known methods and technologies to improve energy use efficiency requires an understanding of how these forces operate and how changes in these forces will influence energy consumption patterns and fuel use. The regulatory policies and programs of various agencies need to be critically reexamined to see how they can be modified to promote greater energy efficiency. To accomplish this, identification of a lead agency which will decide on the trade-offs among separate agency interests and establish an overall government posture is a key requirement. Guidelines in (Public Law 93-577, Sec. 5(a), imply a strong ERDA role.

QUESTIONS

1. Has ERDA developed programs to analyze nontechnological issues related to energy use?

z. What fraction of its energy budget will be assigned to analyses of economic, social, institutional, and behavioral issues?

3. What efforts does ERDA anticipate to evaluate the energy impacts of Federal regulatory programs? Will the efforts involve the cooperation and participation of other Federal agencies? If so, how?

4. How can the administrative costs of regulation to the taxpayer, the manufacturer, the businessman, and the consumer be assessed?

BACKGROUND

Energy conservation analysis which focuses solely on the technological issues and neglects the many nontechnological considerations is incomplete and undesirable. Research on the effect of Government regulatory agencies, as well as studies of the social factors which influence energy use patterns, would be particularly timely. For example, the Interstate Commerce Commission regulates all rail and much truck freight traffic in addition to intercity bus travel, The Civil Aeronautics Board regulates commercial aviation, The Federal Highway Administration and the National Highway Traffic Safety Administration regulate truck weight and safety features. The Urban Mass Transit Administration, and a bewildering array of local regulations, control the operation and labor practices of urban transit systems. Almost none of these emphasize energy conservation. Similar examples can be cited for the other areas of concern.

R, D&D required to carry out programs in conservation is strongly sector-specific, whether it be in technology, social science, or behavioral science. It is encouraging to note that conservation work is organized along sector lines.

The policies, programs, and regulations of these agencies need to be reexamined to see if recent and projected changes in fuel prices and availability warrant modifications to promote greater energy efficiency, It is likely that these analyses can best be conducted in cooperation with other interested Federal agencies, such as the Federal Energy Administration and the regulatory agencies.

6. Demand Modeling and Conservation Planning

ISSUE

The basic assumptions underlying ERDA's projections of future demands are unrealistic; as a result, the ERDA Plan has not accorded sufficient attention to conservation as a means of reducing energy demand, environmental impact, and financial stress.

SUMMARY

Investment in energy conservation can yield a high rate of return. In addition to lower total cost for a given standard of living, major benefits which result from conservation efforts include:

- Lower energy and natural resource consumption
- Lower capital investment requirements
- Reduced environmental impact,

The Reference Energy System model used in the ERDA Plan as a "baseline" reference for future energy demand growth is unrealistic in that it does not recognize the impact of even current price increases on future demand. As a result, an artificially high demand is projected for 1985 and 2000, and this inflated figure is the basis from which plans for new supply are developed,

Program emphasis and funding may thus be seriously biased toward the supply options. Such an overstatement of need is damaging to future efforts toward energy development in both the supply and demand areas. Since the ERDA Plan is closely tied to numbers generated in the model, we must be careful to keep in mind the assumptions that went into the ERDA calculations.

QUESTIONS

1. ERDA depends rather heavily on the Reference Energy System model to provide estimates of oil and gas imports required under varying assumptions about supply and conservation actions. It is realistic to project that no increases in end-use efficiency will occur (other than with respect to the automobile) over the next 25 years unless the government takes additional actions? In other words, is Scenario 1 more likely to be the "no-action" response?

2. Some industries have already reported gains in energy efficiency (energy use per unit output) that approach the figures projected by the ERDA Plan for 1985. Given present prices plus an (assumed) active Federal program to accelerate conservation, would ERDA expect significantly greater gains in end-use efficiency than assumed in Scenario 1?

3. What plans exist to refine demand projections? How are they related to projected population growth and composition, individual income, and other demographic factors? Is the data available sufficient to describe present energy consumption patterns, let alone project future demand?

4. Has ERDA based its planning and establishment of priorities on consideration of the economic and environmental implications of reduced demand (conservation)?

5. Does the ERDA Plan place too much emphasis on "creating" energy choices and not enough on evaluation of energy options for "trade-off" between options?

6. There are several national energy models at several Federal agencies, notably ERDA and FEA. What continuing coordination arrangements should be made to ensure maximum productivity y and minimum duplication of effort?

BACKGROUND

The ERDA Plan uses a "scenario" approach to calculate national consumption and associated demands for oil and gas imports under various assumptions. Five scenarios are examined, plus a baseline called "no new initiatives" (Scenario O). In Scenario O, ERDA assumes that current consumption patterns continue to the end of the century in all end-use areas with the single exception of a 40-percent improvement in average new car efficiency by 1980, The resulting total energy demand in 1985 and 2000 lies comfortably in the middle between results of "predictions" by others.

Even if current real energy prices remain constant (a very optimistic assumption], consumption patterns will surely continue in the years ahead to shift toward lower demand growth, This is largely due to "lagged response," which means that a consumer's ultimate response to changes in real energy price occurs over a period of up to 10 to 15 years, and that only a small percent of the total response is evident in the first year following a price shift. Therefore, Scenario O does not provide a realistic baseline. If the baseline demand scenario is unrealistically high, the importance of reducing imports and, therefore, the urgency of the need is to increase supplies and reduce demand is inflated.

Conservation Scenario 1 (Improved Efficiencies of End-Use) assumes only very moderate improvements in use. For instance, an average 10-percent improvement in appliance efficiency is assumed by 1985. Such levels of improvement are sufficiently conservative that a very modest national effort can probably achieve the scenario, In fact, it is not unlikely that the shift to higher efficiency assumed in Scenario 1 will occur simply in response to price increases which have already occurred. Similarly, the effect of the high "baseline" in Scenario O is to overstress the urgency of the need to expand domestic supplies in order to hold down imports. Therefore, ERDA should use more realistic parameters for the baseline and conservation scenarios on which to base future program plans and priorities,

In addition, ERDA's projections are based on insufficient data and exclude such factors as the inherent economic and environmental advantages of improved efficiency, The Brookhaven National Laboratories models were used to evaluate the supply/demand picture for 1985 and 2000. Inputs to these models include end-use demands. The model then estimates energy conversation and supply technologies to minimize cost. End-use behavioral and technological changes are not adequately included in the model. For example, the demand assumptions in the conservation scenario of the ERDA Plan project changes in the efficiency of end-use devices but do not consider the effects of design, control, and operational changes, or the influence of the price mechanism. These are significant omissions, particularly in the building sector.

A more useful approach would include the use of a predictive demand model to evaluate the related economic and environmental benefits associated with reduced consumption. These have a significant multiplier effect in reducing supply requirements; a barrel of oil saved will often reduce supply requirements by more than a barrel. A similar situation exists for economic considerations. For example, as conservation is applied to building heating and cooling, capacity requirements are reduced, providing dollar savings. The latter are further increased by operating energy cost savings over the lifetime of the buildings. The direct reduction of environmental impact also provides energy savings.

The development of a data base on energy use patterns as well as improved predictive models is essential to energy demand projections, future program planning, and conservation evaluation, ERDA, in conjunction with other Federal agencies, should undertake the development and refinement of these data and methods.

7. Design Methods and Standards

ISSUE

Energy conservation efforts in the building and consumer products sector require the development and dissemination of analytic design methods and the adoption of reasonable energy standards.

SUMMARY

In order to realize the full potential of energy conservation in the building and consumer product sector, two major tasks must be accomplished. First, the design profession must be provided with improved design methodologies, as traditional design procedures do not place adequate emphasis upon energy considerations. A fundamental reorganization of the design process and the development of new energy-sensitive analytic tools is required. Second, realistic energy standards and/or energy budgets must be established as design guidelines. Data on existing energy use patterns in the buildings and consumer products sector must be analyzed in order to develop a rational basis for new standards. Finally, fundamental questions as to the form energy standards should take must be resolved, The ERDA Plan does not give sufficient emphasis to this need.

QUESTIONS

1. What methods will ERDA employ to establish standards and/or energy budgets and to determine conformance to established standards?

2, Is there a constructive role for ERDA in improving performance evaluation techniques?

3. How will standards be applied to diverse climatic areas and energy use patterns?

4. What role does ERDA intend to play in the educational effort necessary to reorient design toward energy efficiency and conservation?

5. How does ERDA plan to assure a reasonable level of energy accounting in the building and consumer products sector?

BACKGROUND

In most instances, energy use data, improved methods of analysis and design, and the basic elements of realistic standards do exist. However, as the building and consumer products industries are fragmented and have very diverse needs, the data are scattered, and the energy-sensitive methods of analysis and design are frequently not well understood. While many professional societies and manufacturing associations have already adopted standards which, if applied uniformly, would contribute significantly to energy conservation, these efforts have not, in many cases, been coordinated; thus, standards and design procedures within the industries are not consistent, Some standards are prescriptive or specify component performance. Some standards have been proposed for "energy budgets." The General Services Administration has developed a target budget for new office buildings. Standards and guidelines for existing buildings have received even less attention,

A definite role for ERDA exists in this area of concern. Without the development and dissemination of reliable methods of analysis, as well as the adoption of reasonable and uniform standards, energy conservation efforts will be frustrated. Moreover, architects, engineers, and many of the small industrial concerns in this sector are unable to support the major research efforts necessary; thus, a strong lead by ERDA is required.

Development of standards should be approached with great care, Prescriptive standards that specify components and systems will tend to freeze the state-of-the-art of the then existing, energy-using mechanical and electrical systems, On the other hand, performance standards which establish broad energy goals within a framework of human needs for comfortable working and living environments will allow design professionals and the building industry the latitude needed to develop innovative and efficient solutions.

The issues relating to the establishment and implementation of energy standards are as follows:

- Are the data on the energy requirements of buildings and various consumer products sufficient to provide a realistic basis for establishing standards?
- What form should such standards take? Should they be prescriptive or performance standards? Will voluntary standards suffice?
- How should these standards be promulgated? They must become an integral part of building codes, conditions for mortgage loans, and so forth, or they will not be effective,
- Once promulgated, how will architects, engineers, and inspectors be trained? What manuals need to be developed to aid implementation?
- Do designers have the analytical tools necessary to assure that their designs meet the intent of energy standards, or is an educational effort required?

8. Development and Demonstration

ISSUE

ERDA's plans for R, D&D of energy conservation technologies in buildings and consumer products should be accelerated and expanded.

SUMMARY

In order to introduce the current technology into society as fast as justifiable by market economics and national need, demonstration projects must be developed for use in all sections of the Nation, ERDA's plans for the implementation of existing technology for energy conservation in buildings and consumer products appear inadequate: in addition, it is evident that ERDA is not spending a sufficient portion of its resources on the research of new energy conservation technology which holds great promise for the future.

QUESTIONS

1. What plans does ERDA have to ensure that the planned major solar heating and cooling demonstration programs place sufficient stress upon insulation and other energy-conserving instruments that must compete for the same capital?
2. What plans does ERDA have to study existing buildings for effective energy use?
3. Does ERDA plan any basic research on human factors in order to reevaluate the thermal and visual requirements for comfort, health, and safety ?
4. What potential exists for the application of energy storage to conventional heating and air conditioning systems?
5. If current refrigerants prove to have adverse environmental effects, what are the possibilities for the development of new, effective substitutes'?

BACKGROUND

The ERDA Plan does not appear to give sufficient attention to the need to develop programs designed to demonstrate current energy conservation technology to the public. Congress has legislated a demonstration program for solar heating and cooling, Perhaps that program could be modified to include more explicitly architectural design and thermal engineering, so essential to the economic viability of solar utilization.

Many of the technologies required to enable major conservation in the building and consumer products sector now exist and can be demonstrated and brought into the marketplace more rapidly than solar power systems.

In the near term, the barriers to implementation are primarily nontechnical. However, future national energy goals can best be met only by a program that includes sustained conservation efforts. Great long-term gains may be achieved through an appropriate investment in basic research, The present ERDA plan gives little consideration to basic research relevant to conservation technologies. Examples of areas where new technologies may provide additional energy savings in the building and consumer product sector are (some of them are in ERDA's Plan):

- Thermal energy storage systems compatible with conventional heating and air conditioning equipment.
- Development of more thermally efficient building materials: improved insulation; glass product-s; and selective surf ace materials for solar radiation control.
- Research on human factors, such as people's adaptability to their thermal environment.
- New approaches to high efficiency appliances, including lighting.
- Chemically stable fluids for heating and air conditioning applications, having useful thermal properties.

Until recently, efficiency of energy consumption in buildings was of little concern to the architect, builder, or consumer. The ineffective use of buildings contributes to their inefficient use of energy-based systems. The redesign and replanning of existing buildings (especially the 24 billion square feet of commercial and institutional buildings) poses a major challenge to the Nation's design professionals. R, D&D must be done for both new buildings and retrofitting existing buildings. It is likely that the research which permits the new building contractor to install energy efficient systems will not be directly transferable to the retrofitting of old structures. Therefore, it is good to note that ERDA will initiate research in FY 76 designed to determine how buildings can be retrofitted in a cost-effective manner.

In terms of the specific programs in the ERDA Plan the following observations are made:

- Demonstrations of energy conservation technology in buildings and solar heating and cooling demonstrations, should be more closely coordinated; demonstrations should emphasize the total building system.
- The delay of construction and evaluation of minimum energy buildings until 1978 and novel building design until 1980 seems unnecessary.
- Research into new building materials and systems should be accelerated.
- More emphasis should be placed on research of lighting systems and cost-effective ways to reduce energy use in present lighting systems.
- A program for the evaluation and demonstration of energy storage in buildings as an adjunct to conventional heating and cooling should be developed in the near term as a way to respond to time-of-day electrical rates,
- Research on the energy efficiency of energy-intensive consumer products should be intensified in this fiscal year if possible.

9. Constraints in Building Construction

ISSUE

ERDA does not appear to be devoting sufficient effort to overcoming the nontechnological barriers to energy conservation in building construction.

SUMMARY

The technology to permit substantial reductions in energy expenditures on commercial and residential buildings is currently available. New technologies and designs promise cost-effective reductions of energy to operate buildings of 60 percent or more. However, five primary nontechnological barriers impede this objective and require R, D&D to provide ways to overcome them:

- The minimum first-cost syndrome.
- Antiquated local building codes.
- Poor system design.
- Industry and consumer resistance.
- ERDA's budget control procedures.

QUESTIONS

1. What are the barriers to more rapid implementation of existing technologies in buildings? What is the role of ERDA relative to:
   - Industrial acceptance of technologies designed to foster energy conservation.
   - Financial incentives for design and construct ion of more energy-efficient structures (e.g., life-cycle cost rather than first-cost analyses)?
2. How can building codes be modified to promote energy conservation?
3. How can the design processes be redefined to optimize the building and its energy system as a whole?
4. What research has been done, or is planned, to identify barriers to consumer and industrial acceptance of minimum life-cycle cost decisions in housing and appliances?
5. What incentives will be most effective in gaining consumer acceptance?
   - Must incentives vary with socioeconomic factors?
   - What meaningful incentives can be identified for the commercial sector?
   - Would incentives vary with type and size of commercial organization?
6. What steps are being taken to assure the Nation that the research results of ERDA programs for energy conservation in buildings and community systems can be promptly and effectively utilized by design professionals?

BACKGROUND

The technology which can save substantial (20 to 30 percent) energy in commercial and residential buildings in a cost-effective way is already available. Five major factors are presently inhibiting conservation in buildings:

- First-cost Syndrome, There is still a feeling among many builders that buyers are not willing to pay for the extras that will save them substantial amounts of money in the long run. Under present financing conditions, buyers effectively use a very high discount rate in home purchase decisions regarding mortgage versus operating costs. In the commercial sector, most financial considerations have the net effect of encouraging the landlord to make the lowest possible capital investment. As a result, builders in both the residential and commercial areas tend to use materials and building techniques that cost least in the short run and to ignore operating costs. Therefore, a major ERDA effort should be directed toward undertaking the research and educating the public, lending institutions, and building owners with regard to the opportunities to make cost savings through retrofitting or special measures in new building construction which save energy. Where possible, new construction should be life-cycle costed; that is based on minimum total cost of mortgage plus operations and maintenance. Research should also be done to determine how both builders and buyers can be made aware of the advantages of life-cycle costing.

- Building Codes and Standards. There are two problems with existing building codes in the United States. First, they are inconsistent from community to community, thereby making the introduction of new concepts on a national level difficult. Second, many building codes and construction standards were not developed with energy conservation in mind. ERDA should study this “constraint” upon energy-efficient buildings so that strategies to overcome this problem can be developed,

- System Design. Designers should regard energy conservation as an integral part of the overall building design, While some professional architectural and engineering firms are already active in energy conservation design programs, the great majority have not yet been adequately prepared to undertake the challenges posed by energy conservation in designing new communities and buildings, or redesigning existing communities and buildings. A major program is required to promote the effective utilization of the research results which Federal agencies and ERDA, in particular, will produce.

- lndustrial and Consumer Acceptance, Very little research has been done to determine the barriers to industry (producers, builders, and professionals] and consumer acceptance of new conservation techniques and to devise incentives which could be used to overcome these barriers. Some of the barriers to industry acceptance may include: lack of knowledge, lack of proper retraining, capital constraints and improper regulations. In addition, in order for new energy conservation in buildings and consumer products to be fully integrated into society, an effort must be made to understand the barriers to acceptance of these items by the final consumers. It is important that the final consumer understand the implications of energy conservation in the home. In order to overcome these barriers, incentives which should be considered would include retraining programs for industry personnel, tax credits, tax writeoffs, accelerated depreciation, and guaranteed loans. Research is necessary in order to determine precisely which incentives are most effective for the different sectors of the building industry and the various socioeconomic segments of our society.

- ERDA’s Budget Control. The review of ERDA’s program generated a concern regarding the adequacy of AEC-type budget control and contracting procedure when applied to the fragmented, small business components of the building industry. AEC’s control procedures were designed to deal with large corporations capable of carrying the capital outlays required. AEC then reimbursed the firm involved when the equipment, construction, and so forth were completed. Those problems can be overcome by establishing alternate procedures applicable to the segmented building industry, ERDA may wish to establish procedures which would help to eliminate the need for short-term capital as one of the major non-technological barriers to demonstration of energy conservation,

10. Need for Thermodynamic Analysis

ISSUE

The ERDA Plan does not describe how the agency plans to identify areas with the highest theoretical potential for industrial energy conservation and to assess the practical feasibility of implementing programs in these areas.

SUMMARY

Prior to establishing research priorities in industrial energy conservation, a detailed assessment must be made of the amount and form of energy used in industry and the efficiency of industrial energy use. Thermodynamic analysis, which determines the theoretical minimum energy required for a given process, may be used to identify areas having a high theoretical potential for energy savings. Once promising areas have been identified, however, the feasibility of these improvements must be evaluated to determine whether economic, political, or social restraints might render a proposed solution useless, even if it is technologically possible. Such considerations must enter ERDA's program planning activities early in the cycle to assure ultimate utilization of research results.

QUESTIONS

1. What efforts are planned by ERDA to establish priorities for R, D&D programs in industrial processes?
2. What procedures will ERDA establish to evaluate the nontechnical (economic, environmental, etc.) aspects of energy conservation technologies identified by a theoretical minimum energy consumption analysis?
3. How does ERDA propose to utilize existing "minimum energy" analyses (e.g., the FEA studies of Energy Use Data for Nine Industries]?
4. Do adequate methods presently exist to predict accurately the effects that a proposed change in some industrial plant might have on, say, jobs or air quality?

BACKGROUND

For any industrial process, well-established energy accounting procedures can show at what point in the manufacturing sequence energy is consumed, how much is consumed, and in what form. However, such procedures will not indicate the theoretical minimum energy consumption required, thermodynamically, to carry out the process. In evaluating the energy conservation potential of a process, it is therefore necessary to distinguish between the conventional energy losses which occur in process operations and the theoretical energy losses inherent in any process involving thermal energy. For example, conventional energy losses are due to mechanical or fluid friction, to heat losses through the walls of equipment, or to waste steam being exhausted to ambient air or process cooling water. Theoretical losses, on the other hand, are those which are inescapable in any given process even with the best engineering and operating practices. These losses are imposed on the process by the Second Law of Thermodynamics, which deals with the impossibility of the total conversion of heat to work, Thus there is a definable theoretical minimum energy requirement for performing a given process. The potential for energy conservation for that process is a function of that theoretical minimum energy requirement and the energy actually required in manufacturing plants,

In performing a "minimum energy" analysis it must also be recognized that energy loses "quality" or capacity for performing work as it passes from stage to stage in a manufacturing plant. The usefulness of the energy in 30000 F flame is greater than that in a stream of waste cooling water at 100° F, even though the energy release, in terms of Btu per hour, may be the same. The concept of "cascading" energy from stages requiring high grade energy to those requiring lower grade energy is very valuable as a conservation option in many industrial processes.

Once the theoretical potential for energy conservation is established, the problem of implemental ion of energy conservation strategies must then be addressed. While the ERDA Plan cites the identification of energy savings opportunities as a major ERDA role, little is said about the problem of feasibility analysis to determine the acceptability of a proposed solution, For example, "cascading" of heat uses may save a lot of energy but could require a capital investment too large to be economically feasible.

In the near term, energy conservation goals in industry may be met by what might be termed "housekeeping" measures, that is, relatively simple fixes to energy-wasteful equipment and operating procedures, Such measures have already accounted for energy reductions of 10 to 15 percent below levels of a year ago, by many companies, with some companies reporting even better results. In the longer term, however, major process revisions and equipment replacement will be required. These changes will, in most cases, necessitate large capital expenditures, which must be justified in economic as well as energy terms. In some cases, environmental and social factors will also influence these decisions,

ERDA should include the development of tools for feasibility y analysis as a part of its comprehensive plan; these should encompass economic modeling of industrial processes under varying energy cost assumptions, and environmental and social impact assessment methodologies. These tools will be of value not only to industry but also to ERDA itself in the selection of projects with a high probability of success. Furthermore, such models would be useful as policymaking tools, since they would permit policymaking agencies (such as Federal Energy Adminstration, for example) to study possible alternative incentive measures for industrial investment.

11. Oil and Gas Substitution

ISSUE

ERDA's plans for the substitution of other energy sources for oil and gas as part of the industrial conservation "program are not well defined.

SUMMARY

Conservation strategies as defined by ERDA can take two forms:

- Conservation of energy by increasing efficiency of end use.
- Conservation of scarce resources, such as oil and gas, by substituting other energy sources, such as coal, nuclear, or organic wastes. Although ERDA is obviously aware of both of these options, the plans spelled out in the industrial sector do not clearly distinguish between them. ERDA should examine the potential and the impacts of fuel substitution in various key industries, and formulate the specific R, D&D strategies required, Possibilities exist for the production of process heat for industrial users by nuclear- and coal-fired plants. Also the use of synthetic fuels derived from coal, such as low-Btu gas, may prove to be an economical substitute for oil and natural gas in many applications. In the mid-to-long term, as advanced electric generating technologies reach commercialization, industries may shift to electricity for process heat and steam generation. With research and development, high-capacity high-temperature heat pumps may be able to provide process heat with an efficiency comparable to that of direct fuel firing,

Questions

1. What potential does ERDA project for the use of coal as a substitute for oil or gas in the industrial sector? What programs are proposed to achieve this potential?

z. How will the research being performed under the Assistant Administrator for Fossil Fuels be coordinated with the work in conservation?

3. How will ERDA assess the potential of direct nuclear heat and steam generation as a valid option for conserving limited fossil fuels?

BACKGROUND

Over 80 percent of the energy in the industrial sector is derived from oil and gas. Various possibilities for substitution exist. Coal, for example, can be used to generate process steam, although new technologies, such as fluidized bed combustion, would greatly aid in assuring that environmental standards can be maintained. Conceivably, coal could also be used in process furnaces but not without considerable R, D&D. The use of synthetic fuels from coal for industrial boilers or furnaces is another important possibility as discussed in the fossil section. This option depends on the economics of the various coal conversion processes, such as the production of low-Btu gas for industrial furnaces. While much R, D&D is underway in this general area, specific applications in the industrial sector should be investigated, with appropriate participation by the industries concerned,

A number of studies have been carried out to determine the feasibility of direct use of nuclear heat for process applications. The operating temperature limit of light water reactors restricts their area of potential use to process steam generation. Because of the economic advantage of large scale operation in nuclear plants, it would be necessary to site a number of large customers in close proximity to the nuclear plant, This is the scheme pursued by Consumer's Power and Dow Chemical in Midland, Mich.

Technology is available to utilize organic wastes to generate steam; this, in fact, has been done in the pulp and paper industry, the chemical industry, and others, The principal barriers to further implementation are socioeconomic and should be studied.

Another long-range opportunity for efficient provision of process heat will be the development of high-capacity high-temperature heat pumps to absorb heat from low-temperature process streams and deliver it to higher temperature sections of the process. This concept will require a program of research in thermodynamic properties of potential working fluids, material physical properties, and process optimization, to be carried out via a coordinated government industry effort. The potential gains are significant. For example, a heat pump designed to absorb heat from one stream at 3000 F and deliver it to a stream at 600°F could theoretically transfer more than three times as much heat as the electric energy required to drive it. Realistically, if 60 percent of this theoretical performance were achieved in practice, the heat pump would still provide over twice as much heat input to the process as direct electric heating. With advanced electrical generation systems offering efficiencies in excess of 50 percent, heat pump systems could thus be competitive with direct fossil or nuclear heat sources on an energy-used basis.

12. Use of Foreign Technology

ISSUE

The ERDA program should consider the utilization of foreign technology as an alternative to new conservation research.

SUMMARY

The ERDA Program proposes new research in a number of areas in which technological innovations are already either under development or in operation in foreign countries. The adoption of such innovations should normally take priority over new research initiatives, since the former are cheaper and can impact faster **on** industry. Successful utilization of certain technologies may eliminate the necessity for research in peripheral areas which bear on the same basic problems.

While adoption of technology developed abroad may simplify the technological research problem, a number of institutional barriers may have to be overcome before successful implementation can be accomplished.

QUESTIONS

1. What provisions have been made in the ERDA Plan to assure that we utilize, to the fullest possible extent, energy conservation innovations developed in other countries?
2. What sorts of institutional restraints might impede the use of foreign technology in attacking some of our own problems? Does the ERDA's Plan include provisions for seeking to ease these restraints?
3. What provisions will ERDA make for the funding of cooperative R, D&D programs with government agencies of foreign countries? What value does ERDA place on such cooperative ventures?

BACKGROUND

While the need for energy conservation may seem new to the United States, where domestic resources have been relatively abundant, conservation in many areas of the world, in particular, Western Europe, has been a way of life for decades, The need to preserve scarce resources has fostered many innovations in energy conservation, and a wealth of experience is available (see Appendix). For example, Germany and France have used municipal refuse as a supplementary fuel source in industrial heating for many years; these installations provided the primary basis for much of the design of the well-known Union Electric/St. Louis project. It is noteworthy that this project has proceeded immediately to commercial scale without requiring expensive and time-consuming pilot operations.

Another example is a system of active load control used by electric utilities in West Germany, in which high-demand appliances may be remotely controlled by signals sent out over the distribution network. If the system is shown to be attractive for use in this country, the im-

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plementation of such an existing technology might be assigned a higher priority than research on new systems designed to fulfill similar objectives.

A vigorous effort to use foreign technology will involve exploratory assessment, investigation of legal factors, and dissemination of the technology, These functions might be carried out either within each ERDA division or in a separate group devoted exclusively to foreign technology.

Some Examples of Foreign Technology Opportunities*

	Item	Examples of Applications (Companies, Locations, etc.)
1.	Cement kiln preheater technology	Japan (developed by Mitsubishi, IHI, etc.) Europe (developed by Polysius, Humboldt, Krupp, F. L. Smidth)
2.	Use of blended cements (with fly ash, blast furnace slags, etc.)	Europe in general (e.g., new blended cement specifications recently introduced by France)
3.	Ceramic recuperators for steel industry applications (soaking pits, etc.)	Developed by British Steel Corporation and installed at Llanwern Steel Works
4.	Oxygen enrichment of copper smelter combustion air	Canada
5.	Dry coke quenching for integrated steel plants	Australia (Wagner-Biro), Switzerland (Sulzer), Russia [through Machine-export)
6.	Energy recovery from blast furnace gases by use of turbines	Japan (IHI)
7.	Use of noncoking coals in blast furnaces	British Steel Corporation
8.	Higher efficiency slab reheating furnaces in steel plants	British Steel Corporation
9.	Ore pelletizing processes for preparation of blast furnace feed	Sweden (COBO process, Glangcold process of the Granges Company)
10.	Agricultural, aquacultural, and district heating applications using industrial waste heat	Germany and U.K.
11.	Cement plant roller mill developments	Lotsche (Germany), Morgardshammer (Sweden)
12.	Improved solvent recovery processes for synthetic rubber precursors and synthetic fiber intermediates	Japan (paraxylene recovery, Japan Gas Co.)
13.	Use of cold in LNG for freezedrying, cold storage, and air separation plants	Japan (Tokyo Gas Co., Japan Super Freeze Co.)
14.	Use of electrical induction heating to replace gas-fired furnaces in heat treating applications	Switzerland (Brown-Boveri)
15.	Techniques for electric utility plant load leveling	Europe in general, such as compressed air storage (Nordwest deutsche Kraftwerke, Germany) and use of offpeak power for cement clinker grinding
16.	Recovery of low-grade waste heat using freon turbine cycles*	Japan (Ishikawajima Harima Heavy Industries]

*Many of these technologies are also being used in American industry.

13. Transmission and Distribution Priorities

ISSUE

The economic, environmental, and reliability criteria underlying ERDA's choice of projects and their relative priorities in the electrical transmission and distribution program need clarification.

SUMMARY

As the demand for electricity increases, and the shift from oil and gas to coal and nuclear fuels proceeds, additional electric transmission and distribution capacities will be needed. This increased capacity must be economically justifiable and environmentally acceptable, The ERDA transmission program does not address directly the relative benefits and difficulties of the successful development of various candidate technologies.

QUESTIONS

1. Do the priorities in the ERDA program take into account the relative probabilities of success of the various transmission alternatives?
2. Has ERDA assessed the economic, reliability y, and maintenance problems associated with commercial utilization of cryogenic and superconducting transmission lines in comparison with less complex alternatives?
3. If superconducting systems prove technologically feasible, has ERDA determined how they may be practically integrated into the power systems?
4. What is the justification for Federal expenditures in electrical transmission and distribution research? Is this area not adequately covered by research in the private domain?

BACKGROUND

As increased transmission capacity is needed within the Nation's electric systems, existing technologies may be unsuitable for satisfying the demands. Additional overhead lines may be unacceptable for environmental and land use reasons. ERDA has, therefore, begun programs on overhead a.c. and d.c. transmission, and underground transmission including superconducting technology, However, the relative emphasis and the likelihood of success of various approaches being pursued are not made clear in the ERDA plan.

A.c. overhead transmission is the method in general use today for delivering large blocks of power over long distances. The expected trend toward large generation parks, large distances from loads, will require higher transmission voltages to accomplish this energy transfer economically using a minimum number of lines.

Overhead d.c, transmission has proved a viable alternate to a.c, in many situations and it is generally more efficient and ecologically more accept able, in that, large ambients electromagnetic fields in the vicinity of the lines do not exist. To take full advantage of d.c, transmission, technology must be advanced beyond the present point-to-point transmission to allow full network advantages as well as transmission at higher voltages,

Underground transmission at higher voltage and capacity levels is virtually nonexistent because of the high cost. Systems must be developed so underground transmission can provide efficient transmission at a reasonable cost from rura1 to urban and city areas in a continuous pattern.

The possibilities now evident for these advances are (1) conventional cables with improved cooling, (z) compressed gas insulated cables, (3) resistive cryogenic cables, and (4) superconducting cables. While several of these possibilities appear very attractive, the cost of research and prototype construction and demonstration is very high, hence this is an important ERDA responsibility,

In general, overhead a.c. transmission technology holds the highest promise for cost effective transmission, but environmental and other constraints, such as land use, demand that new alternatives be developed to provide options for the future.

14. Active Load Management

ISSUE

Active load management in electric power systems is not addressed as a cost-effective way to save energy.

SUMMARY

The problem of meeting large peak demands in electric power systems affects both the fuel consumption and the total capital investment required for generating plants. Energy consumption is affected because peak demands are met with a utility's least efficient generating units (i. e., those units kept off-line until needed for peaking), or by units such as gas turbines which have a low capital cost and low efficiency. Furthermore, large coal and nuclear units are not well-suited for peaking service; hence, peaking service is most commonly accomplished with gas and oil consuming equipment. Equally important, capital, materials, and manpower of the very kind needed for energy resource development, are conserved when the addition of new generating equipment can be slowed down by means of improved load management.

Several options exist for reducing peak load growth. Electrical demand at the end-u se point may be controlled through the use of utility-operated remote controls on large consumption devices, by thermal storage at the use point, and by electrical storage in substations. Peak demand, which is more costly than average demand, may also be controlled through the use of rate incentives to encourage more uniform energy consumption, While some relevant experience exists in the United States and abroad, further technological, economic, and social evaluation is needed to achieve widespread implementation.

QUESTIONS

1. Have alternatives to central station energy storage been considered in the ERDA Plan to reduce power generation requirements in electric power systems?
2. How soon might active load control systems be made available in the United States and when implemented, what impact might such systems have on system load factors, gas and oil demand, and capital requirements for new electric peak power generations?
3. What technological, economic, social, and legal barriers exist which would impede the institution of rate structures designed to encourage better load management by consumers? What incentives do utilities have to improve efficiency through load management?
4. Does ERDA have a well-defined role in studying the feasibility of time-of-day pricing?
5. What are the implications of time-of-day and seasonal pricing on various sectors of the economy?
6. Have public awareness schemes, such as prominent electric meters in homes, been investigated as possible incentive programs for load leveling?

BACKGROUND

Load leveling or “peak shaving” has been used in the United States only for very large industrial customers, while it is practiced on a broader scale in Western Europe, Australia, and some other countries. Because the load characteristics of other countries are sometimes quite different from those in the United States, it is difficult to estimate without careful analysis the total potential savings due to load control. It is clear, however, that present use patterns are costly, in terms of both energy and capital; and furthermore, the form of energy used for peaking is usually gas or oil, our scarcest resources. One approach to the problem is to provide some means of storage, such as batteries, which can be charged during off-peak hours and used as a supplemental power source during peak hours. The alternative approach, and one for which much of the basic knowledge is either available or near at hand, is to control load at the end-use point rather than simply providing the means to meet an uncontrolled load. This may be done by fitting on-off controls to major energy consuming devices, such as large air conditioning compressors and electric water heaters, which can be remotely activated for short periods by the generating utility or by automatic timing devices when total system loads exceed desired levels. This may usually be accomplished with almost negligible effect on the service delivered by such devices.

Another approach to load control is to devise a time-dependent rate structure which encourages users to spread their utilization of energy out over the day (e.g., to avoid use of clothes driers during the afternoon). This can be accomplished by time-of-day pricing to motivate off-peak energy use and flattening of the load curve.

In addition to direct savings in energy, time-of-day and seasonal pricing would save substantial capital cost outlays for the electrical companies. As demand is leveled around the day and year the utility companies will be able to operate with a higher capacity factor. It has been estimated that as much as $50 billion could be saved in the United States over the next decade through active load management* or by reducing the rate of new construction required to meet growing peak loads; but this projection lacks substantive economic analysis.

Both active and passive control strategies need research, testing, and evaluation before broad-scale implementation can be realized. Encoding, metering, and signaling devices must be developed and evaluated; incentives for passive controls will need evaluation through the use of econometric models, which also need further development. Technologies that will enable customers to respond productively to such changes in rates need to be developed.

*Projections of FEA’s Task Force on Electric Utilities, 1975.

15. Orientation of Automotive Programs

ISSUE

ERDA's program on highway vehicles is directed more toward prototype development than toward the technological breakthroughs necessary for successful commercialization.

SUMMARY

ERDA's program in automobile, truck, and bus research emphasizes the development and demonstration of major hardware systems (e.g., gas turbine and Stirling engine-powered automobiles, flywheel prototype car, hybrid bus powerplant, 60-mile range electric car, etc.) using state-of-the-art technology. The ERDA Plan gives no indication that payoff is likely to result from such R, D&D through the commercial introduction of more energy efficient vehicles, Obstacles which blocked the commercialization of the proposed systems in the past are not addressed, and therefore, it seems doubtful that these technical, economic, or environmental impediments will be removed by the proposed R, D&D programs. ERDA should focus its attention less on production prototypes and more on long-term, basic supporr ting technologies.

QUESTIONS

1. How does ERDA establish its priorities in advanced automobile technology?
2. Why does ERDA concentrate so much of its effort on the development and demonstration of prototype vehicles?
3. What is the likelihood that these programs will lead to the successful commercialization of alternatives to the internal combustion engine?
4. What impact will ERDA's automotive programs have on the energy problem?

BACKGROUND

The major thrust of ERDA's conservation program on highway vehicles appears directed towards the development and demonstration of hardware. The list of projects on the development of powerplants as possible alternatives to the spark-ignited engine is broad: gas turbine, lightweight diesel, Stirling cycle, battery and flywheel powered vehicles, Most, if not all, of these technologies have been extensively studied in the past, either in this country or abroad, and have been found to possess serious problems that blocked their commercial introduction in this country. While the cost of energy and the seriousness of the present energy problem can change the importance of various options, ERDA has not shown why the likelihood of successful commercialization of any of the projects proposed is appreciably greater now than in the past. The ERDA program does not identify the obstacles which continue to impede their introduction, nor how they propose to address these factors.

Most experts in automobile technology feel that at the present level of funding, ERDA is destined to cover much of the same ground that has already been studied by industry. The market conditions have not changed sufficiently, nor is the depth of research and development sufficient to create a serious competitor to the internal combustion engine.

While a Federal R, D&D program in advanced automobile technology can make a valuable contribution to meeting national objectives in energy conservation, it appears unwise for the program to focus on production prototypes having to compete in the marketplace against the present, highly optimized automobile. A more realistic and useful approach would be to engage in a stable long-term program with an emphasis on supporting, supplementing, and stimulating R, D&D efforts in the private sector. While this is a less glamorous strategy than prototype development, it is more likely to yield significant results in the future, The programs should focus on the early stages of development and on those areas where technological advances could make an important impact on future automotive systems. ERDA is presently engaged in some of these types of projects, such as those on ceramic materials for gas turbines and the sodium-sulfur battery, but, overall, the program lacks the appropriate emphasis and balance.

16. Cooperation With the Transportation Industry

ISSUE

Successful commercialization of ERDA-sponsored technology in the transportation sector will be achieved more readily with close cooperation between ERDA and industry.

SUMMARY

Industry involvement in the commercialization of ERDA-sponsored technology, such as new and improved automotive powerplants, is critical. While technology transfer within a given organization is difficult, transfer between two different organizations, such as ERDA and the automotive industry, is vastly more difficult. To alleviate this problem, ERDA should solicit industry advice and input during the program planning stage; this input might consist of ERDA contracts with industry in the areas of feasibility, assessment, and systems planning, or of joint 13 RDA/industry advisory groups. Various constraints upon joint interaction exist, such as antitrust considerations in the automotive industry. Nevertheless, early industry commitment to commercialization is essential to the successful transfer of ERDA-sponsored technology to industry,

QUESTIONS

1. How can ERDA encourage private industry to become intimately involved with its energy conservation programs, thereby ensuring maximum utilization of the program's results?

z. Should industry have a financial interest in those ERDA programs which may yield commercially applicable technology?

3. At what point should ERDA funding on a program be stopped and commercialization of the findings left to industry?

BACKGROUND

For ERDA-developed energy conservation technology to receive maximum attention by private industry, ERDA's programs must be planned, monitored, and evaluated with a maximum of industry input. ERDA and private industry have to achieve a mutually satisfactory partnership that recognizes each other's needs and makes the best possible use of the taxpayer's investment. Costly ERDA demonstration projects may not be necessary if industry is given the opportunity to evaluate the commercial viability of newly developed energy conservation technology,

In order to maximize the chances for commercial success, both ERDA and private industry should consider changing some of their past practices. For instance, ERDA must involve industry in the early stages of its major energy conservation research and development program planning. Industry should be asked to outline its major energy conservation research and development needs, to assign priorities and commercialization potential estimates to each of the needs outlined, and to recommend basic research areas that could find widespread utility. In addition, industry should identify programs that it can carry out without ERDA's assistance. Some of ERDA's currently planned demonstration programs can and are being done by industry because they are close to or at the commercialization stage.

In those instances where ERDA's programs are similar to programs previously carried out by industry, ERDA should provide industry with incentives to divulge its previously unreported findings without having to relinquish any vested patent rights. Many industry programs are not carried through to commercialization because of technological difficulties or unrewarding economics. Now that the cost of energy has risen drastically and energy efficiency has become a more important criterion, these programs are receiving renewed attention. However, the originally developed information regarding these programs may not be available in the technical literature because of the stigma associated with negative results and unsuccessful programs, This information may now prove extremely useful to an organization starting a "new" program in one of these areas.

Specific examples of industrial programs which were not commercial successes and were not extensively reported in the technical literature include the continuously variable transmission, heat storage devices, and rotary engines. There are probably many other examples obtainable via careful inquiry into prior industry knowledge of areas now receiving renewed attention because of their energy conservation potential.

Excellent examples of technology transfer from government to industry exist, such as the NACA program, predecessor of the National Aeronautics and Space Administration. The key organizational features of this program were the joint committees, which helped to define the program, and the steering committees, which monitored the progress and output, thereby facilitating rapid technology transfer where appropriate.

The present ERDA program in the transportation sector represents, in effect, the transfer of an existing program from the Environmental Protection Agency (the American Association for the Promotion of Science program), When the program was in the Environmental Protection Agency, industry reviewed its output and concluded that the program had not yielded significant results.

17. Nonhighway Vehicle Transportation Program

ISSUE

ERDA presently has no program for energy conservation in the nonhighway vehicle transportation sector.

SUMMARY

Although railroads, pipelines, waterways, and airplanes carry many of the passengers and much of the freight in this country and use a substantial quantity of petroleum fuel, the ERDA conservation program virtually ignores this sector. There is immediate need for the assembly of an adequate data base and for systems studies to identify the areas of greatest potential fuel savings. In addition to performing this analysis, ERDA must possess the capability to cooperate with and, in some instances, coordinate the efforts of other Federal agencies toward energy conservation in this sector.

QUESTIONS

1. What plans does ERDA have for the assembly of a data base for nonhighway transportation systems?

2. What specific systems studies are under way or contemplated for the evaluation of fuel savings potential in this sector?

BACKGROUND

It is estimated that some 25 percent of the fuel consumed in the United States for transportation is in the form of petroleum used for nonhighway systems, These uses include oil, gas, and slurry pipelines as well as rail, water, and air transport systems, In addition to direct fuel savings from improved efficiency, modal shifts and improved load factors offer economically feasible improvements in energy usage.

In order to identify areas in which substantial fuel savings are possible and to develop implementation strategies, research should begin immediately toward the establishment of an adequate data base and toward the systems analysis of existing transportation networks, Both a cross-sectional and a time-series data base are required to delineate present fuel consumption patterns and to give baseline information against which improvements can be measured.

Systems studies are needed to identify opportunities for significant improvements and to evaluate proposals such as:

- Modal shifts, for example, from highway to water transport for bulk materials, and from highway to rail for passengers
- Advanced technology, for example, highspeed ground transportation for both passengers and freight
- Multimodal terminals for both passengers and freight
- Federal transportation grant programs and other proposed schemes for Federal participation in nonhighway transport R, D&D
- Modifications in transportation regulations to give higher load factors, for example, in passenger airlines and other improvements,

It is important that ERDA avoid duplicating the work of industry and of other agencies, such as industrial locomotive development and the National Aeronautics and Space Administration or the Department of Transportation research and development in air transport. Because of the huge potential for savings, however, it is necessary that ERDA develop the capability to assess fuel usage, determine opportunities for improvement, coordinate its conservation efforts with other programs in industry and government, and stimulate the development of new technology where needed.

18. Energy Recovery From Waste

ISSUE

ERDA has formulated no plans or programs in the productive use of waste although specifically directed to do so by Congress.

SUMMARY

ERDA is mandated by law (PL 93-577, Sec. 6(b)(3)) "to assign program elements. . . to advance energy conservation technologies including but not limited to productive use of waste, including garbage, sewage, agricultural wastes, and industrial waste heat; reuse and recycling of materials and consumer product s," The ERDA programs in ERDA-48 vol. II make no mention of any such activities.

QUESTIONS

1. Why has ERDA no plans in the productive use of wastes?
2. In relation to other Federal agencies, what is the appropriate ERDA role in the area of R, D&D in energy and resource recovery from municipal solid wastes?

BACKGROUND

ERDA has a statutory requirement to conduct R, D&D for solid waste energy and resource recovery. Principal waste energy sources are municipal solid wastes, biomass waste, and organic sludge. Currently, municipal wastes are being burned with coal to make electricity in one city; in another, these are burned to produce steam and to chill water for district heating and cooling. Authoritative projections indicate that the annual contributions to national energy supply from the burning of municipal wastes could be about 0.5 Quad in 1985 (maximum 0.8 Quad). Although the amount seems relatively small, it equals that of geothermal potential for the near term, Indirect but nonetheless significant additional energy savings can be made from recovery of materials (e.g., aluminum, iron) from the nonfuel fraction.

There exists a question of whether ERDA is giving sufficient attention to solid waste energy and resource recovery R, D&D. While the ERDA FY 76 budget shows token consideration ($300 K) for these activities, ERDA-48, vol. II does not discuss them. Successful R, D&D in this area will expand the amount of resources available for energy production; cause less pollution of land, air, and water; and as an added benefit, help diminish the volume of waste to be discarded, In addition, such a program can also be helpful in improving reuse and recycling systems, producing further savings of energy, and reducing environmental impact, since the collection and separation process for municipal wastes would facilitate aggregation of various kinds of materials. ERDA's program should reflect a higher degree of concern for this area,

Chapter VI

Environmental and Health Task Group Analysis

A. ENVIRONMENTAL AND HEALTH TASK GROUP

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B. ENVIRONMENTAL AND HEALTH TASK GROUP ISSUES LIST

1. **Environmental Impacts of High Voltage Transmission Lines . . . 217**

   The environmental and safety impacts of high voltage electrical transmission lines are not sufficiently known.

2. **Ground and Surface Water Contamination From Surface Mining . . 218**

   Research on the potential environmental problems from surface mining is inadequate, particularly in terms of impacts on ground and surface water quality.

3. **Energy Consumption and Inadvertent Climate Modification 220**

   More needs to be known as to whether long-term environmental impacts of increasing worldwide energy use can lead to detrimental or irreversible climate modification.

4. **Variance on Environmental Standards During Development 221**

   present environmental regulations with regard to the functioning of environmental control equipment are inappropriate to effective technology development at the pilot plant level.

5. **Energy Modeling and Data Bank Requirements 223**

   It is not clear from the ERDA Plan and Program that critical needs in energy modeling procedures and the associated data requirements are fully recognized and accepted by ERDA,

6. Site and Technology-Specific Nature of Cause-Effect Relationships In Environmental and Health Impacts .*. **** **** *.** .**. e** 225

   Simple extension of energy systems modeling capabilities to the regional discrimination level with expanded emissions categories will not yield a valid impact profile for energy technology decision-making.

7. **Integration of Environmental, Health, Social, and Institutional Research Into Technology Programs 227**

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8. **Energy Impacts of Air and Water Pollution Control Regulations . 229**

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    Social and institutional research is needed to identify potential constraints on the deployment of offshore energy facilities,

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12. **Pro ram Focus in Fossil Fuel Health Effects Research 236**

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C. INTRODUCTION

The Environment, Health and Safety section of this report contains discussions of issues in the title categories which relate to more than one of the energy research and development areas in the ERDA organization or which are general to the whole topic of energy research and development from the purview of environmental, health or safety considerations. Environmental and health issues specific to individual technologies or energy resources are discussed in those sections of the report, with cross reference as appropriate to this section.

The issues identified in this section fall into four major topical areas: environmental impacts of alternative technologies; systems aspects of environmental impact assessment; institutional problems relating to environmental, economic and social issues; and health factors relating to energy resource development and applications of energy systems. The principal conclusions derived from this work are briefly summarized in the following paragraphs.

Technology Issues

The ERDA Plan is heavily weighted toward electrification of energy-consuming activities. Implied in this emphasis on electrification is a requirement for extensive additions to the electrical transmission network and a shift to ultra high voltage transmission to reduce" transmission losses. While interest and program objectives concerning biological, health and environmental impacts of high voltage transmission technology are stated in the ERDA program, no explicit scheduling or resource information appears in the ERDA documents to relate those programs to the schedules and decision points in the high voltage transmission technology programs (Issue 1).

In resource recovery and mining, only limited attention is being paid to mining and associated ground-water pollution, with inadequate effort devoted to the definition of hydrological baseline data (Issue 2). Potentially irreversible climate modification on a global scale is a risk of continued efforts to meet increases in energy demand. ERDA has not developed a program to examine the relative heat rejection and atmospheric pollutant emission consequences of new technologies, especially the "inexhaustible" but highly inefficient processes, and their potential impact on global climate balance (Issue 3).

Environmental quality regulations in their present form are designed to protect the environment and the public health by limiting the emission of pollutants from potential sources. The necessary programs to develop new energy technologies and the environmental control technologies associated with them could be severely hampered by inflexible application of the current environmental regulations (Issue 4].

Systems Aspects of Environmental Assessment

It is not clear from the ERDA Plan and Program that critical needs in energy modeling procedures and the associated data requirements are fully recognized and accepted by ERDA (Issue 5), There are serious questions concerning the impact on air quality of the addition of new energy facilities to the existing field of air pollution sources. Simple extension of energy systems modeling to the regional level will not yield a valid assessment of potential environmental impacts (Issue 6).

The ERDA Program document contains an extensive description of proposed activity in environmental, health, social and institutional topics. Almost all of this description occurs in the sections of the report devoted to Environment and Safety and Systems Studies. Discussion of these topics in the sections of the report devoted to technology development generally consisted of one-line statements recognizing the existence of a potential constraint. There was no reference to the environmental or health research programs in the schedules appended to technology-oriented sections. Interviews with ERDA personnel yielded the strong impression that the stated objective of integrating the environmental control research into the technology development is at present illusory. Given that environmental, health, social and institutional problems are likely to impose serious constraints on implementation of ERDA's programs, much better integration of these concerns into the pursuit of the technology programs themselves is indicated (Issue 7).

Existing regulations concerning air and water quality and some which will become effective in the next few years may impose significant energy costs or environmental impacts in categories which are not encompassed by the regulating agency. There has been no systems evaluation of the interact ions between environmental regulations and their total effect. This is a valid and important area of inquiry for ERDA which has not been addressed (Issue 8).

The problems of water availability for coal conversion to liquid or gaseous fuels, shale oil retorting, electrical generation by any means and other energy oriented activities will have to compete with other uses for water in water-short areas (Issue 9). These same activities and associated mining and waste management operations may impact water quality in the same areas, thus potentially affecting agriculture and domestic and municipal water supplies.

Social and Institutional Issues

The entire discussion of interagency activities in the Program document indicates poor coordination between ERDA and other agencies and equally poor definition of jurisdictional responsibility in critical areas of cooperative effort on potential environmental, social and institutional problems. These problem areas will probably pose the most serious constraints to implementation of ERDA's programs in several technology areas and may jeopardize the achievement of ERDA's goals if not properly addressed in a timely manner (Issues 8, 10, and 11),

Health Effects Issues

At this time, the adequacy of air quality regulations concerning sulfur dioxide is being questioned [Issue 14). The complex interaction between sulfur oxides and other constituents in the atmosphere, natural and man-induced, is the subject of extensive study by EPA, ERDA and others. The outcome in terms of sulfate standards for protection of public health and environmental quality is unknown, but could have a serious constraining effect on achievement of ERDA's Plan, which relies heavily on coal in the near and intermediate term. The health programs relating to potential new chemical intrusions from coal conversion and oil shale programs, some of which may be potent carcinogens, were also questioned (Issue 13). In the general area of health studies, there is little evidence of a serious effort to define the relative priority between programs. There are also indications that ERDA is involved in programs which do not relate to its energy mission and needs to reassess the usefulness of other programs in terms of the validity of the results these programs will yield (Issue 12).

D. ENVIRONMENTAL AND HEALTH ISSUE PAPERS

1. Environmental Impacts of High Voltage Transmission Lines

ISSUE

More explicit program planning is needed to relate High Voltage Transmission Line Program objectives and decisions to related research and decisions on biological and environmental impacts.

SUMMARY

While the ERDA Plan states program objectives on the biological, environmental, and health impacts of high voltage transmission technology, it does "not present explicit scheduling or resource information to relate such programs or findings to the schedules on decision processes of its high voltage transmission technology programs.

QUESTIONS

1. What potential effect could the ERDA biological, environmental and health investigations have on the contracting and implementation milestones shown in ERDA's technology program schedule for high voltage transmission?

z. At what level, in what facilities, with what manpower, and under which ERDA division will the environmental, biological, and health research on high voltage transmission be performed?

BACKGROUND

Along with the possibility of developing electrical power transmission lines operating at voltages as high as 1,500 KV comes the possibility of related adverse impacts on human health and on other biosystems. Sufficiently strong electromagnetic field gradients imposed by the transmission lines on plants and animal life in the nearby environment may induce internal currents which can affect the vital functions of the plant or animal organism. While knowledge is incomplete about the threshold and magnitude of such effects in humans, it is suspected these produce impacts on the nervous system, digestive system and heart. The environmental effects of possible corona discharge and ozone gas production are not adequately known. Consideration of such effects is a vital element in the design, construction and installation of high voltage electrical power transmission systems. Integration of the necessary environmental research results into the technology program is essential for valid program evaluation and decisionmaking.

2. Ground and Surface Water Contamination From Surface Mining

ISSUE

Research is inadequate on the potential environmental problems arising from surface mining, particularly in terms of its impacts on ground and surface water quality.

SUMMARY

Large-scale surface mining of fuels to the extent necessary to meet ERDA's energy plans presents the potential for generating large amounts of a variety of pollutants that will be difficult to control by point-source control technology. Examples of this type of pollution are the leaching into ground and surface waters of sulfates, nitrates, ammonium, acids, and trace metals from strip mines and reclaimed areas.

The type of pollutants generated can vary from area to area depending upon geology, topography, and climate. The development of predictive models to evaluate the types and amounts of potential pollutants will ease the development of the technology needed to control and minimize these discharges.

QUESTIONS

1.. What is the effect of large-scale surface mining operations in the West on ground and surface water quality in the Missouri and Colorado River basins?

2. What impacts will changes in ground and surface water quality from large scale surface mining operations have on farming and ranching in the West, and on forestry, agriculture, and municipal water supplies in the East?

3. In what geographic areas is it necessary to replace topsoil to insure the productivity of the land, and in what areas will replacement of topsoil be unnecessary?

4. To what extent and in which areas will mining-induced water pollution limit energy development?

5. Which agency should take the leadership role in research relating to environmental impacts of surface mining operations, and what should be its relationship to other Federal and State agencies?

BACKGROUND

The ERDA plan to increase the production of coal, lignite, and shale oil fossil fuels will require extensive increases in surface mining operations in both the East and the West. These strip mining operations can significantly alter, through exposure to the atmosphere and rainfall, the geochemical environment of the overburden material that remains after the coal is extracted, Chemical changes which can occur include the oxidation of pyrites to sulfuric acid, ferrous iron, and sulfate ion; oxidation of ammonium ion to nitrite and nitrate ions; leaching of trace metals from the overburden; and the dissolving of cationic and anionic constituents from coal and soil, which increases salinity levels. The possible release of radioactive isotopes and trace metal constituents from uranium surface mining operations poses an additional problem in South Texas and the Rocky Mountains.

The problems to be faced vary with geographical regions, acid mine drainage bring a greater problem in the East and salt leaching a greater problem in the West. Environmental concerns so far have primarily centered on acid mine drainage in the East. There has been inadequate concern for the effect of large-scale surface mining on groundwater quality and the potential pollutants that can be leached from reclaimed areas. The large scale centamination of ground and surface waters from surface mining operations is a problem which is not easily amenable to existing control technology. The adverse effects on ground and surface water quality can impair subsequent use of the water for farming and ranching, forest productivity, and municipal and domestic drinking water supplies.

Predictive techniques need to be developed to assess, prior to their initiation, the potential for generating pollutants from specific surface mining locations. Extensive data are available on background levels of groundwater and surface water quality and geochemical make-up of overburden material, Some data are available on the impact of reclamation and surface mining, but these data sources are widely distributed through numerous State and Federal agencies and universities, The collection of these dispersed data, plus the collection of necessary additional information, will permit a nationwide determination of additional impact study needs.

3. Energy Consumption and Inadvertent Climate Modification

ISSUE

Not enough is known about the potential for detrimental or irreversible climate modification caused by increasing worldwide energy use over the long term.

SUMMARY

Changes in rainfall and temperature associated with increased energy consumption have been observed in specific localized areas. Evaluation of the potential for large scale changes in climate caused by escalating energy use requires a better understanding of the Earth's ultimate capacity to assimilate man-made heat, While the ERDA plan paid some attention to the relation between energy use and local meteorological changes, it does not address the larger question of the ultimately sustainable level of thermal loading.

QUESTION

1. Considering the difficulty of the problem and its potential importance, why has ERDA not initiated a program to study the problem of ultimately tolerable thermal loadings?

BACKGROUND

The current and anticipated thermal loadings associated with worldwide energy use represent potentially significant influences on local, regional, and worldwide meteorological conditions. Although every energy production method ERDA is considering could add to this loading, large scale climate change processes are not now sufficiently well understood to make quantitative predictions, The need for better understanding of these processes, however, is emphasized by the relatively short time periods (one to two centuries) which may be characteristic of the initiation or termination of ice ages.

During 1970, average worldwide, man-made power densities amounted to only 0.054 w/sq.m. By contrast, solar-energy input into the outer atmosphere is 340 w/sq. m of which about 158 w/sq.m is initially retained in the atmosphere or initially absorbed on the surface of the earth. Power release densities associated with human energy use have exceeded the average normal solar power input in some metropolitan areas for more than a decade, in some cases by substantial margins (Moscow by about a factor of 3 and in Manhattan by more than a factor of 6 during the 1965-68 period). By the year 2000, such heavily industrialized areas as the Ruhr Valley in Western Germany will produce thermal loads over a wide region which exceed the normal solar input by about a factor of 10, while new power generation from nuclear farms, currently being considered for implementation, will generate thermal loads that are 100 times larger than "normal. "

4. Variance on Environmental Standards During Development

ISSUE

Present environmental regulations on the functioning of environmental control equipment may tend to deter the development of new energy technologies at the pilot plant level.

SUMMARY

Development of necessary environmental control equipment can be as difficult and uncertain as the development of any other technology. The present regulatory climate in the United States does not provide for pilot plant development programs as special cases. Coupling the development of new energy technologies with that of their associated environmental protection technologies, as regulations now require, may seriously hamper ERDA efforts to bring new energy sources to commercial use. This presents a risk of abandoning potentially viable energy technologies because faulty performance of experimental environmental control equipment compromises (the proof-of-process) results obtained in pilot plant testing of the basic energy technology. ERDA should address the question of the environmental risks and ad hoc mitigating measures which may be appropriate in pilot level development. With the Congress and the regulatory agencies, ERDA should explore the advisability of special regulations for pilot and demonstration facilities.

QUESTIONS

1. What consideration has ERDA given to pilot plant development problems which could result from the parallel operation of experimental energy-associated and environmental control equipment?

2. Have the possibilities for flexible environmental regulations and necessary precautions for experimental facilities been explored by ERDA with other agencies such as EPA?

BACKGROUND

The development history of flue gas desulfurization methods shows that development of ancillary environmental control equipment can be as difficult and traumatic as the development of the basic process itself. It is almost axiomatic that the scaling up of a process from the typical laboratory experimental level to a facility size which can begin to demonstrate the commercial economics of the process involves significant further development effort,

Shale oil retorting facilities, coal liquefaction and gasification processes and other major energy facilities of the sort contemplated in ERDA's programs commonly exhibit problems of process stability or equipment durability, Such problems do not emerge in laboratory-scale experiments. These must be overcome before the process can be applied at the very large scales required t o make production facilities commercially feasible.

Beyond encountering development problems in experimental large-scale energy facilities, there is the equal probability of coming upon similar problems in associated environmental control equipment. By definition, this equipment will have to be tested on the same scale as those experimental energy facilities. The parallel operation of all the equipment together is likely to exhibit further problems. It makes sense to be sure that the primary processes in the technology are technically viable, whether or not the pollutant control equipment has been perfected or its integration into the overall operation has been achieved. The construction of demonstration plants with all environmental control equipment installed, but with the capability to decouple the control equipment, will provide the option to continue testing the technical process should problems be encountered with the control equipment. Pilot plant operation with and without the environmental control equipment will also demonstrate more clearly the true effect of such equipment on the total process. This information would be valuable in later research and development activities.

Any plan to operate a demonstration-level facility in the manner described above would require careful analysis of the level of environmental insult which uncontrolled operation would produce. Also required would be the provision of auxiliary equipment to protect against significant or irreversible environmental damage, risk to health or impact on activities surrounding the facility. Operation with substandard environmental controls would further require special provisions in environmental regulations to permit temporary non-compliance with emissions standards. Such provisions are not presently available to ERDA. The responsible formulation of flexible environmental standards for experimental facilities would assist ERDA in achieving its goals.

5. Energy Modeling and Data Bank Requirements

ISSUE

It is not clear from the ERDA Plan and Program that ERDA fully recognizes and accepts critical needs in energy modeling procedures and in the associated data requirements.

SUMMARY

Linear models, such as the Brookhaven Reference Energy System, used for projecting the ERDA scenarios can easily incorporate probabilistic measures of the accuracy of environmental information. Probabilistic calculations would give a more meaningful projection of future demand as well as pinpoint data which are important but highly uncertain,

A large increase in the number of categories of effluents measured and used in environmental impact modeling is also needed. Using the proposed Brook haven techniques, grouping of compounds results in, for example, the collection of all hydrocarbons in a single category. This procedure facilitates the collection and manipulation of data, but makes conclusions based on such data suspect, because of the substantial variation in environmental effects among the hydrocarbons.

The whole field of energy system modeling is in an early stage of development. ERDA's discussion of modeling recognizes a need for much more sophisticated techniques than those currently at hand. Several energy models are being developed around the country. It would be desirable for ERDA to interface on a continuing basis with these other activities so as to compare the sensitivity of modeling results to alternative techniques and data bases. Consistency of projections from alternative models does not guarantee accuracy. However, in the absence of an existing real basis for calibration, a consensus between independent efforts can increase confidence in the validity of the results obtained.

QUESTIONS

1. Are the energy demand projections in the ERDA Plan based on the best estimate of these values, or is there some conservatism factored in to reflect the Administration's aversion to the risk of energy shortfall?

2. What are ERDA's plans to incorporate in their modeling efforts information on the levels of uncertainty associated with environmental data?

3. The postulating of alternative scenarios is only one of several methods of treating the uncertainties associated with the development of new technologies. What methods will ERDA use to display the sensitivity of their results to changes in the assumptions used and to uncertainties in the environmental data?

4. In view of the number of independent energy system models that are being developed, what plans does ERDA have for making alternative projections?

BACKGROUND

The availability of assured supplies of energy in the future is important to environmental quality. If there is an energy shortfall, there will be pressure to relax environmental controls to alleviate the shortage. In order to avert such energy shortfalls, it is necessary to know in advance the level of energy demand.

One way to bracket future demand is to construct several scenarios for future events, such as those presented in ERDA-48. This is useful in that it shows common features of future activity even when the assumptions about future behavior are quite different. The difficulty with the alternative scenario approach is that it is difficult for decision-makers to assess the most likely conditions from the several scenarios. By estimating the probability of commercial success of various technologies, and using estimates of accuracy of various data, it should be possible not only to develop the environmental consequences of the several scenarios but also to predict the likelihood of occurrence of the situation the scenario projects.

The development of probabilistic scenarios of future energy demand will give decision-makers a view of alternative future effects and their probability y of occurrence. This will be useful for choosing among alternative courses of action. The construction of the scenarios will also point out shortcomings in the data required for forecasting and will serve as a guide for data acquisition.

As the ERDA health effects research programs advance to the point of yielding usable dose-effect information, it will be necessary to continually improve the quality and quantity of the residual materials data used in the Brookhaven environmental data base, The effluent categories will eventually have to be disaggregated to the point where data on different compounds are collected separately. In some cases the necessary information is available; in other cases this disaggregation exercise will point out important gaps in existing information,

Adverse environmental impacts stemming from future energy generation strategies can be minimized if demand levels as a function of time are accurately known. To predict most accurately, one should make energy system projections with a variety of types of available models. The ERDA Plan relies solely on the Brookhaven Reference Energy System, This energy model is a good, national, static model, but it cannot contend with situations that are dynamic. There are regional and dynamic models that can be applied to yield other ideas about the future of the energy system and its environmental consequences.

6. Site and Technology-Specific Nature of Cause-Effect Relationships in Environmental and Health Impacts

ISSUE

Simple extension of energy systems modeling capabilities to the regional discrimination level with expanded emissions categories will not yield a valid impact profile for energy technology decisionmaking.

SUMMARY

Considerable effort has been devoted to determining the rates of emission of various materials from energy conversion devices. These data are by no means complete, but in many cases they are adequate. Much less is known about the actual amounts of environmental degradation resulting from a given emission rate. The prediction of dose is complicated by site specific factors such as population density, climatology and ambient air quality. The further translation from pollutant dose to effect is known only for a very small number of pollutants (SO, ozone, PAN, lead, CO, etc.) and only in terms of their major effects on agricultural products and selected animal species. However, the effects of even these pollutants is not known for low dose levels. Chronic exposure conditions or possible synergistic relationships have seldom been explored. Expanded studies are needed to assess the impact, in quantifiable terms, of the many energy related pollutants at varying emission or release rates, Such studies will improve the effectiveness of modeling approaches and ultimately improve our capability to optimize energy choice/use patterns.

QUESTIONS

1. What new methodologies are being pursued that will lead to effective assessments of the environmental impacts of various scenarios?
2. What type of program is envisioned for determining the extent of the impact on the public of the "new" pollutants deriving from advanced fossil fuel technologies?
3. What efforts are planned to identify the potential environmental and health effects of typical mixes of pollutants associated with advanced technologies (including all the variants of types and control possibilities)?
4. How will data on the many diverse environmental effects of fossil fuels be displayed to al1ow meaningful comparisons in cost/benefit/risk analyses?

BACKGROUND

Many benefits could result from early, consistent, systematic analyses of the environmental effects of energy conversion. The analyses can provide early feedback for design and control options, provide a rational framework for the formulation of regu lations, and be used to initiate well-aimed health effects studies. To be useful, however, the systematic analyses must model the real environmental degradation and not just national or even regional totals for tons of emissions.

It is, unfortunately, extremely difficult to make systematic environmental impact assessments. Reducing impacts to a common denominator, such as dollars, results in the loss of much necessary decision information. A possible format for the presentation of information is a matrix of options and effects.

The Matrix of Environmental Residuals for Energy Systems (MERES) system is a good first step toward the use of the matrix modeling concept. However, it deals only with the total emissions of the scenarios modeled. Simple modeling can grossly mislead any attempt to set emission standards for the protection of the environment or the public health. A serious inadequacy of the MERES effort is its failure to factor in the variations between regions and localities in terms of dispersive potentials, atmospheric chemical transformations, background concentrations of pollutant species, or the nature and density of populations exposed to pollutants. While it is possible in principle to perform a scale-up of regional experience in pollutant loading to obtain better indications of total environmental degradation, such an extrapolation from existing regional conditions presents serious difficulties, The addition of new technologies and new facility sites will change both the configuration of pollutant sources and the mix of pollutants input to the environment. It will therefore be necessary to include site-specific characteristics in any model to be used for predictive analyses in the interest of energy decisionmaking processes.

Definition of alternative specific site types for energy facilities will make it possible to more realistically treat siting constraints such as climatological and demographic characteristics of powerplant environs. Attention to the characteristics of specific potential sites will facilitate the development of an inventory of potential sites for energy facilities. It would then be possible to develop sites in the inventory as the need arises with minimal adverse environmental effect.

7. Integration of Environmental, Health, Social, and Institutional Research Into Technology Programs

ISSUE

ERDA's presentation and discussion of environmental, health, social and institutional research indicates a lack of integration of this research into its R, D&D program.

SUMMARY

To maximize the effectiveness of research on environmental, health, social and institutional constraints, the results of that research should be available before the widespread implementation of the technology. The ERDA implementation schedules do not present environmental and health research timelines in parallel with the technical milestones. Further, the specific plans for environmental and health-related research, tailored to the individual technologies which will be promoted, are not detailed and discussed in the technology program statements provided in volume II.

The failure of volume II to define environmental, health, social and institutional problems which could constrain specific technology programs is a significant oversight. The oversight is emphasized by the established obligation of Federal agencies to consider potential environmental impacts at the earliest time in their planning processes. Explicit priority is given to analysis of environmental and social consequences of energy technology deployment in Section 5 (a) (z) of the Federal Nonnuclear Energy Research and Development Act of 1974. Because of the lack of specificity of the environmental activities defined in ERDA's technology program descriptions, there is no guarantee that the necessary environmental research and assessment will be conducted simultaneously with energy technology development.

QUESTIONS

1. How does ERDA plan to integrate environmental analyses into the development of a technology so that they are incorporated in decisionmaking as each discrete step is taken toward commercialization of the technology?
2. Although the National Environmental Policy Act and the Federal Nonnuclear Energy Research and Development Act both emphasize timely analysis of environmental and social consequences, why is there little detailed discussion of either in volume II's technology program statements?
3. What proportion of ERDA's proposed budgets for technology programs will be spent on environmental, social economic, and institutional analyses?
4. What rationale was used to schedule the environmental and health research required for assessing the suitability of emerging technologies?

BACKGROUND

Whenever a potential environmental problem related to a developing technology is identified, the maximum integration of environmental control technology into engineering design is required throughout the long process of bringing an energy technology to commercially proven levels. Otherwise, costly “add-on” modifications may be necessary as regulatory action or negative public reactions begin to constrain the development process. Adequate continual environmental research, beginning at the earliest time in ERDA’s planning process (as detailed in volume II), is necessary through specifically tailored and detailed projects in order to achieve this goal,

‘l’he NEPA environmental impact statement process already calls on Federal agencies to take environmental factors into account at the earliest possible time in decisionmaking. Federal court decisions, foremost among them being the Scientists’ Institute case, have required that energy research and development programs be covered by impact statements. But the issue raised here goes beyond the impact statement preparation process (although not beyond the NEPA mandate to agencies) to recognition that the environmental research components of overall technology development should actually be written into planning and budgeting documents as integrated and systematically developed items.

The present structure of ERDA does not provide sufficient incentive for the technology divisions to incorporate at a meaningful level environmental control technology into their total development activities. The Environment and Safety Division (AES) is ERDA’s reservoir of expertise in environment and health research, and is responsible for coordinating these activities with other agencies. However, the links between AES and the technology divisions within ERDA appear to be inadequate to ensure the necessary integration of its concerns into the activities of other ERDA divisions.

The discussion of program strategy in the Environmental Control Technology section of ERDA-48 makes the point that “most of the controls technology development funding as well as the manpower resources will be provided by program units under the Assistant Administrator for Conservation, Nuclear Energy, Fossil Energy, and Solar, Geothermal and Advanced Energy. ” However, a careful reading of the various sections of the program volume shows very clearly that the only substantive discussion of needs for environmental, health, social and institutional research is housed in the Environment and Health, Safety and Systems sections of the report. In the discussions of technology programs, the references to these topics are generally restricted to single sentences which state the potential existence of an (uncharacterized) problem or the need to develop “environmentally acceptable” technology. Further, the schedules attached to the technology sections show only the technology development timelines and milestones. Finally, the interviews with ERDA personnel which took place in the course of the OTA review of the ERDA Plan and Program yielded the information that allocation of funds, staff assignments, and program definition by the technology-oriented divisions in the areas of environmental, health, safety, social, and institutional research were ill-defined at best and apparently nonexistent at worst.

A possible solution for this apparent dereliction by ERDA lies in reorganization of the relationship between the Environment and Health Division and the technology-oriented divisions. The technology divisions should be required to discuss in detail—and schedule—the necessary research on items which may constrain the technology development t for which they are responsible. Since it is apparent that the technology divisions do not now have the necessary staff capabilities to satisfactorily accomplish such an integral program definition, the y will e it her have to develop that capability or turn to the Environment and Health Division to provide it. The latter course may be preferable, as it could lead to a more integrated organizational structure in ERDA. The cross-linking of project organizations and specialty staffs has worked well in private industrial corporations and may, if undertaken in ERDA, enhance ERDA’s capability to achieve its goals.

8. Energy Impacts of Air and Water Pollution Control Regulations

ISSUE

The interactions between energy, environmental and economic effects of Federal, State, and local air and water quality standards are not sufficiently understood.

SUMMARY

The enactment and enforcement of air and water pollution control regulations can have substantial impacts upon energy consumption requirements and solid waste generation. These potential impacts will become increasingly important in the future with the decreasing availability and increasing cost of fuel supplies and/or disposal sites. These complex interactions are not presently recognized by existing regulations, which tend to treat air pollution, water pollution, and solid wastes as separate problems unrelated to potential energy consumption requirements. Environmental protection and energy consumption optimization trade-offs are needed,

QUESTIONS

1. What changes need to be made in existing Federal, State, and local air and water pollution regulations regarding the trade-offs between environmental protection and energy con sump t ion?
2. What are the proper criteria for obtaining optimum balance between environmental protection and energy consumption at specific sites, and by whom should they be explored?
3. What improvements are needed in existing air pollution and water pollution control technologies to minimize potential energy cons u m p t i on ?

BACKGROUND

At present, policies which regulate discrete discharges of effluents are based on applications o f ultimate control technology at or prior to point o f discharge, Such stringent controls of both atmospheric and aquatic discharges are necessary in some cases, but no technical basis exists for their wholesale application as presently administered. These effluent controls may requires significant energy penalties, which result in not only additional fuel consumption but also added air pollutant and solid waste generation, Requirements for controls are better established on a technically-based optimization of environmental protect ion and energy consumption requirements,

Comp1iance with both the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500] and the Clean Air Act Amendments of 1970 can have significant impacts on energy consumption. Public Law 92-

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500 established the requirement that closed cycle cooling technology be applied in all thermal power installations prior to 1985, a goal based upon the best available technology. This law would eliminate thermal input to the aquatic environment where aquatic systems could not tolerate additional thermal increases over all or part of an annual cycle, In such cases, the only presently available alternative is the installation of cooling towers. In the majority of existing facilities extensive study has failed to demonstrate adverse changes as a result of thermal discharges. Most important environmental results, such as biocide effects and entrainment and impingement of aquatic organisms associated with the recommended and presently applied control technologies, can be minimized by proper modification of facility design.

Cooling towers function by transferring heat to the atmosphere through evaporative transport. Associated with this process is the potential for climatic changes and the concentration of solids which ultimately require disposal.

It is important to recognize that cooling towers possess associated environmental disbenefits and do not always have demonstrable benefits, and that they further impose a significant energy penalty (5 to 20 percent) on power generation facilities,

The proposed zero discharge requirements on wastewater treatment facilities can also cause substantial increases in the energy consumption necessary for water pollution control, resulting in increases in air pollutant emissions and solid waste generation. The dewatering and disposal of large quantities of solid waste sludges generated by air and water pollution control devices impose similar secondary environmental and energy penalties. Existing nonregenerative flue gas desulfurization systems at coal-fired power plants also impose energy penalties and generate large amounts of solid waste sludges. Energy penalties of 5 to 20 percent can result from lime or limestone sulfur dioxide scrubbing systems in terms of increased gas pressure drops and stack reheating, liquid pumping, sludge dewatering and transportation. Large quantities of sludge require major nearby land areas for disposal or transportation to distant landfill sties,

The need exists for analytical tools to provide for optimization of environmental control processes to minimize overall adverse environmental impacts,

9. Competing Demands for Water in Western River Basins

ISSUE

The limited availability of water in areas such as the Colorado and Missouri River basins will force systems evaluation of net benefit from energy and non-energy activities which depend on water.

SUMMARY

Large amounts of water wil 1 be required from available ground and surface water supplies in the arid Rocky Mountain states for energy production operations such as coal and oil shale mining, slurry pipeline coal transportation, minemouth electric power generation, coal and oil shale conversion to gaseous and liquid fuels, and environmental management of strip-mined areas and spent shale disposal areas. Extensive implementation of these projected energy production activities may adversely affect water quantity and quality for agricultural use in the same river basins. Development of geothermal energy resources, e.g., in the Imperial Valley, could result in either further water demand and water quality impact or in the production from saline water of a supplementary source of freshwater for agricultural use. Extensive analysis of the total system activity in these river basins will be required to ensure that the proposed energy development activities which are actually implemented will result in a net benefit to the country.

QUESTIONS

1. What is the maximum amount of water which can be made available for energy production in the Missouri and Colorado River basins without jeopardizing agricultural operations and other industrial or public demands for water?
2. What impacts upon water quantity and water quality will occur in the Rocky Mountain states from varying levels of energy production, and what impacts will these have on agricultural production and resultant food prices?
3. What are the relative environmental, energy and economic trade-offs of minemouth processing of coal to electrical energy or synthetic fuels in the arid Rocky Mountain states as compared to alternative transportation to water-abundant areas along the Mississippi River or Gulf of Mexico for subsequent processing?
4. What is your estimate for the potential production of desalinated water from geothermal resources in the Imperial Valley of California by the year 2000?
5. What plans does ERDA have for the construction of integrated regional development plans linking seemingly disparate energy technologies?

BACKGROUND

To meet the Nation's energy requirements, the Federal Government plans major use of the extensive coal, shale oil, and uranium resources in the arid regions of the Rocky Mountain States between 1975 and 2000. Projections call for the possible construction of a significant number of coal-fired electric power plants, coal gasification and liquefaction plants, water slurry pipelines, and shale oil processing facilities. These facilities will have significant impacts upon available supplies of acceptable quality water for farming and ranching unless steps are taken to provide for proper development. Possible alternatives include the transportation of coal to water abundant areas for subsequent processing and extensive in-place water treatment and recycling.

Geothermal resource development in the Imperial Valley of California is currently receiving considerable attention from a number of industrial, governmental, and university groups. The importance of integrated regional development for the Imperial Valley is now recognized by a number of people. But the close connection between the potential for water desalination, using geothermal energy, and proposed energy resource development in the Upper Colorado River Basin has not only not been emphasized, it has not even been mentioned in the ERDA plans, Similar arguments apply to other river basins in which major energy development programs are contemplated, Integrated regional planning by ERDA is necessary to ensure that its energy programs actually yield a net benefit.

10. Need for Social Research in Offshore Energy Programs

ISSUE

Social research is needed on institutional problems arising from the deployment of offshore energy technologies.

SUMMARY

Major problems in new offshore development are presented by the social and institutional constraints to developing offshore oil and gas production, nuclear, and fuels transportation facilities. One current major research need is to examine new institutional mechanisms in order to further understand the problems of government management and public acceptability. This research needs to be conducted on national, regional, and local levels.

QUESTIONS

1. What institutionally related research programs does ERDA have for evaluating offshore oil development?
2. What research is being conducted on new plans or arrangements for oil spill clean-up?

BACKGROUND

The present environmental research implementation program does identify research on offshore technologies in five areas: (1) collaborative efforts on hyperbaric medicine for diver safety, (2) new environmental programs to deal with oil well drilling, (3) criteria for offshore power plant siting, (4) aquatic chemistry of pollutants and (5) oil spill prevention and clean-up procedures and techniques. Although the above areas are important, a specific effort is needed which would focus on the social and institutional constraints to developing offshore oil, gas, nuclear, and fuels transportation facilities. Such a research effort requires an interdisciplinary group study of the full range of potential impacts and effects and alternative social and institutional arrangements.

Because this problem deals with both the means by which offshore areas are made available and the way in which technologies are deployed and standards are developed and enforced, the funding and oversight for this research would be an interagency effort. This research would be directly applicable to considerations of innovative siting, leasing, standards-setting, and enforcement procedures, some of which are subjects of current legislation.

11. Effect of Public Attitudes on Program Implementation

ISSUE

ERDA's plan for Energy Research, Development and Demonstration does not include research on how public attitudes and values affect implementation of Government energy plans and controls.

SUMMARY

Public attitudes about the proper role of Government, what constitutes quality of life, and what characterizes important threats to the human environment, greatly affect what Government actions people will support as well as the incentives and disincentives to which they will be willing to respond. ERDA's plan does not appear to include study of energy-related attitudes, their formation, intensity , a-n-d stability, and the impact of information upon attitude changes.

QUESTIONS

1. Since ERDA recognizes the need to maintain freedom of choice of lifestyles, how does ERDA propose to do research on the effect that different levels and kinds of energy consumption will have on lifestyles?
2. How will ERDA present the necessary results of research on public attitudes so that agencies and other policy makers can make judgments about what the public will accept in terms of energy development, conservation regulations, and environmental controls?
3. How well do the environmental impacts which ERDA proposes to predict for various technologies reflect the concerns that people actually have about their environment? What research is planned to discern public attitudes on environmental issues?

BACKGROUND

The desires and values of the public are as fundamental to energy development as is the availability y of fuel resources, capital, manpower, etc. Yet, ERDA's research plan and implementation program anticipate few studies of attitudes which will affect energy choice, For example:

1. The ERDA Plan recognizes as a national goal a need to maintain choice among life styles. To relate energy technology to life styles, it will be necessary to know what levels of energy consumption are essential for quality of life for people of different regions, with different backgrounds, incomes and family size. Much more must be known about those energy use activities which are simply a matter of habit and superficial convenience, Similarly, attitude research would help to identify the energy consuming activities which are important to certain ways of life.
2. The implementation of ERDA's Energy Plan and environmental controls implies an altered relationship of the Federal Government to private industry and to State and local governments. Attitudes held by different publics about the proper role of

Government may serve to impede the growth of Federa1 Government functions or channel Federal Government action into certain acceptable implementation techniques. Efficient implementation of the plan requires research in this area.

3. Environmental quality is a function of people's perceptions and values. It may be that the quantifiabie and measurable environmental impacts of energy development are poorly related to the attributes of their setting to which people are sensitive. Research in this area is necessary,
4. ERDA's mission includes promoting public understanding of science. This function can be performed adequately only when public attitudes about energy technology are researched.

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12. Program Focus in Fossil Fuel Health Effects Research

ISSUE

The ERDA program of research on the health effects of fossil fuels covers a broad range of biological responses and pollutant exposures. Some research areas do not appear to be relevant to ERDA's missions.

SUMMARY

ERDA's overall program of research into the effects of fossil fuel use on health places great emphasis on basic biological mechanisms of response, Certain important areas, such as biological screening, carcinogenesis and mutagenesis, and epidemiological studies, appear to be inadequately emphasized, while other areas, such as research on recovery, treatment, and development of radiopharmaceuticals, may well be unnecessary under the primary mission of ERDA's health research program. The program description gives little detail as to which pollutants will be given highest priority, or on how the results of health effects research will be integrated into the decision process as to which alternative energy technologies to develop. To meet these research demands, there is a critical need for the training of additional cell- and tissue-culture experts, toxicologists and epidemiologists.

QUESTIONS

1. Which pollutants will be given highest priority for evaluation under the various categories of fossil fuel health effects research and by what criteria does ERDA assign these priorities?
2. What is the purpose in ERDA's mission of research on treatment of and recovery from health effects?
3. How will ERDA's health research program, which is largely directed toward animal models, evaluate known adverse effects on human health which cannot yet be modeled with animal experiments?
4. What plans does ERDA have for training programs to provide the additional manpower needed for their proposed health effects research programs?
5. If ERDA obtains positive results on screening for detrimental effects of a fossil fuel product, how will the results be validated with respect to human populations?
6. What plans does ERDA have to evaluate the safety of substances in humans, once they have successfully passed through the animal screening system?

BACKGROUND

ERDA's FY 1976 program plan for research on the health effects of fossil fuels provides for $32.5 million (including pass-through funds) to be nearly evenly divided between research directly applied to the health effects of fossil fuel technologies ($16 million). These funds were programmed as follows:

I.	Technology-Oriented Objectives	Million $
(1)	Screening for hazardous agents	1.9
(2)	Fate metabolism of hazardous agents	0.9
(3)	Pathophysiological effects including respiratory taxicology	3.3
(4)	Carcinogenesis	1.3
(5)	Mutagenesis and developmental effects	1.5
(6)	Molecular and cellular mechanisms	4,0
[7)	Recovery from and treatment of pollutant-induced health effects	1,0
(8)	Epidemiological studies	2.0
	SUBTOTAL OF I	15.9

II.	Supporting Research	Million $
(1)	Research on critical organ systems of response	3.0
(2)	Improved bioassay screening system	2.4
(3)	Genetic research	1.3
(4)	Molecular and cellular studies	9.9
	SUBTOTAL OF 11	16.6

From the program description, the following issues have been identified:

(1) Selection of Pollutants: It is not clear which pollutants will be evaluated under the various research approaches listed above. High temperature combustion processes using most fess i 1 fuels result in widespread population exposure to sulfur and nitrogen oxides, while exposure to polycyclic hydrocarbons, generally associated with cancer induction will be more 1 i m i ted to relatively small occupational groups, Low temperature combustion reverses this pattern. In general, emissions of heavy and trace metals from energy sources tend to add relatively small increments to population exposures, whereas food chains and water present much larger avenues of exposure.

(2) Research on medical treatment: The ERDA health program includes research on medical treatment, that is, methods to remove metals from the body or to detoxify chemicals in the body. The rat ion ale forth is research program in an agency whose mission is the development of energy technology is unclear. Recovery and treatment may be inherently outside the scope of ERDA's health research responsibilities.

(3) Epidemiological studies: Animal models have been notoriously ineffective in predicting human response to long-term low levels of hazardous agents, particularly those associated with chronic degenerative noncancerous diseases such as coronary heart disease, emphysema, bronchi t is, and arthritis. Air pollution studies have shown that elderly persons which chronic degenerative diseases are among the most succeptible segments of the population with respect to community levels of air pollutants. These findings were derived through extensive epidemiological investigations; primary air quality standards are largely based on epidemiological information. Since animal models of chronic degenerative diseases will probably not be developed in the near-term, it appears that ERDA's health program would be enhanced by placing considerable y greater emphasis on systematic epidemiological research on population and occupational exposure to fossil fuel pollutants.

(4) Screening for hazardous agents: ERDA has programmed $1.9 million for systematic biological screening of hazardous agents in process streams and effluents from various fossil fuel energy technologies, and another $2.4 million to improve methods of detection and monitoring for damage to human populations. A large portion of the $1.9 million systematic screening effort is devoted to screening for mutagenic and carcinogenic agents. This program is smal1 relative to the number of pollutants associated with fossil fuel technologies. TO date, most of the recognized adverse human responses to fossil fuel pollutants have been noncancerous. Many more insidious potential

hazards are known to exist. Sulfur and nitrogen oxides have exerted their primary effects on respiratory airways and lung tissue in the form of causing or contributing to the development of acute and chronic respiratory diseases, including asthma, bronchitis, and emphysema. How ERDA proposes to incorporate these known and potential adverse health effects into its systematic screening program is unclear.

(5) Pathophysiological Effects Including Respiratory Toxicology: This program is largely designed to obtain dose-effect relationships from toxicological studies on animals. Inhalation studies will be emphasized. How the dose-effect data obtained from animal studies will be extrapolated to man, so that the information can be used to control or restrict emissions from a given fossil fuel technology, is unclear,

13. Inadequate Inventory of Skills and Techniques in Health Effects Research

ISSUE

Means are not available to estimate effects of coal combustion and conversion on human health. A broad-based research effort, in both university and Federal facilities, is critically required to develop improved techniques for evaluation of health impacts from coal combustion and conversion.

SUMMARY

The Health Studies Section of ERDA-48, volume II, emphasizes research in the area of longterm effects of coal-related pollutants. This emphasis on cancer and birth defects is most appropriate, since coal-related pollutants are known carcinogens and mutagens. The program, however, appears to stress traditional long-term animal experimentation. This approach cannot yield relevant data in time for decisions about national energy prerogatives. The program also suggests the use of recent research developments in the field of animal cell genetic assays. These show great promise as relevant bioassay systems and should receive greater emphasis. An intensive broad-based effort should be used in both data acquisition and innovative fundamental research. A significant increase in both the scope of the related ERDA research organization and the university production of trained researchers will be needed to meet the research program requirements.

QUESTION

What plans does ERDA have to stimulate the availability of trained researchers with skills other than those represented by former AEC activities; especially in the fields of mammalian genetics and cell biology?

BACKGROUND

The primary public health justification presented in ERDA-48 for research in the area of coal-related pollutants is damage to skin and respiratory systems. The probability of "secondary site for damage" for latent diseases, such as cancer and birth defects, is mentioned but not " emphasized. Emissions from all steps of coal processing release known lipid-soluble cancer-producing substances which are readily diffused across membrane barriers.

No data is available regarding the effects of coal-related pollution on human cancer and birth defects. There is in the public health research area a strong historical preoccupation with respiratory dysfunction. However, if the appropriate criteria for establishing priorities encompass severity and magnitude of effects and the urgency of information acquisition, the strong emphasis on respiratory disease over the more insidious (but later appearing) effects, such as cancer and congenital disorders, is difficult to understand. The reorientation of preexisting AEC programs to the study of coal-related pollutants implies that this step will give ERDA the technical competency required. No misconception could be more damaging to ERDA's health research effort than to assume the presence of adequate scientific manpower in preexisting facilities. The most careful scientific review of the "reorientation" process should be carried out by non-ERDA oncologists (cancer researchers) and geneticists to identify areas of competence and suggest which areas must be implemented by university or other Federal laboratories. This point is doubly important because the "retraining" process may delay the necessary health assessments and will certainly prevent the rapid entry of young researchers because of the priority accorded to existing laboratories. In addition to the redirection of current research personnel, a significant increase in the training of new researchers through the university systems would appear to be necessary. The training process using current university facilities will require the better part of a decade to implement and will take a realistic specification by ERDA of the manpower needs and the desired university response through the 1980's.

As an example, the study of enzymatic reactions involved in metabolizing aromatic polycyclic hydrocarbons to powerful cancer-causing species is not represented in present ERDA facilities. However, strong programs in this area exist at McArdle Laboratory, Rockefeller University, MIT, and La Roche Laboratories, which could contribute to the necessary studies. The pattern of this example is repeated in other specific research areas.

The Health Studies Section of volume II shows a strong emphasis on animal studies in tox-ecological research on the effects of exposure to pollutants. The statement that "no mammal is a sufficient model for man" is a well-documented toxicological fact won by decades of comparative studies in drug metabolism and DNA repair. The stated intent in the ERDA program to add several admittedly inappropriate studies of nonhuman species in order to gain data relevant to man is clearly illogical as well as expensive.

This traditional toxicological emphasis is inappropriate in a program demanding relevant data for a large number of coal-linked pollutants acting singly and in concert. The data from whole animal studies simply would not be available in time to guide decisionmaking in choosing among the various energy scenarios. Several years are required for evaluation of single substances using present FDA procedures. This part of the proposal seems to be planning research to fit existing facilities rather than fitting the public health needs,

To circumvent this difficulty, the encouragement of research in human genetics using the techniques of cell biology may offer a realistic solution. This approach is proposed by ERDA, and reflects well on the breadth of their proposed research, but its relative importance could be strengthened in the proposed program.

14. Atmospheric Sulfates as a Potential Constraint on ERDA's Fossil Fuel Program

ISSUE

Suspected health hazards of atmospheric sulfates may result in air quality standards which would constrain ERDA's programs based on coal.

SUMMARY

Questions have been raised concerning whether sulfate concentrations (as an index of SO_2 transformation products) throughout the mid-west and northeast may presently exceed threshold concentrations for adverse health effects. If substantiated, this finding would raise serious questions as to the advisability of introducing any new sources of sulfur oxide emissions into the atmosphere. There are considerable uncertainties about the concentration and chemical nature of atmospheric sulfates which are hazardous to health. Improved information on the relation of toxicity to sulfate concentrations is required to set ambient air quality standards. If the present fears are supported by scientific findings, standards could be set which would severely limit further energy development programs based on coal as a primary fuel, on direct utilization of geothermal resources, and on approaches to reduce automotive emissions. Immediate and concentrated attention to this area would help to resolve the existing uncertainties. Some of the energy goals set by ERDA, if pursued in the absence of the necessary health effects information on atmospheric transport and transformation of sulfates, may not represent an achievable objective.

QUESTIONS

1. What priority has ERDA set on resolution of the unanswered questions concerning sulfate reactions and transport in the atmosphere and consequent levels of health hazards?
2. What is the status of cooperative efforts between ERDA, EPA, and other agencies involved in sulfates research?
3. What is the perceived need for funds to achieve the earliest possible resolution of unanswered questions concerning sulfates, relative to the present funding level in ERDA and elsewhere?
4. How would a moratorium on additional input of sulfur-bearing compounds to the atmosphere from new facilities affect the ERDA Plan?

BACKGROUND

Sulfur dioxide has long been recognized as a pollutant of major concern, and has been singled out as one of the air pollutants most necessary to be controlled nationwide. Sulfur dioxide was one of the first pollutants for which national ambient air quality standards were established, A concerted effort was carried on from 1970 to the present to substitute low sulfur fuels for high sulfur coal and fuel oil. Significant reductions in sulfur dioxide emissions were achieved.

When the air quality standard for sulfur dioxide was established, it was generally recognized that SO_2 was an index for the class of pollutants emitted largely by fossil fueled power plants. Particularly in the animal toxicological effects area, SO_2 gas alone did not appear to have great toxic potential at ambient or near-ambient levels. Yet epidemiological studies revealed significant correlations between ambient SO_2 levels and adverse health effects.

The resolution of this contradictory evidence was first suggested in the toxicological studies of Dr. Mary Amdur, who showed that sulfuric acid, ferric sulfate, zinc ammonium sulfate, and other oxidation products of $S0_2$ caused an irritant response in guinea pig lungs at much lower concentrations (20 to 100-fold" lower) than SO_2 gas alone. Further, the irritant potency of SO_2 gas was increased 3- to 4-fold in the presence of high humidity, suggesting that the conversion of SO_2 to sulfuric acid aerosol greatly enhanced the biological reactivity of the sulfur oxides. These experimental findings have been confirmed by others.

These animal studies are supported by preliminary epidemiological results obtained from EPA's CHESS program. Among the various air pollutants measured, including SO_2, total particulate, NO_2 and suspended sulfates, concentrate ions of the latter group of atmospheric pollutants were associated with daily aggravat ion of asthma and of cardiopulmonary disease in the various study areas. Daily concentration of SO_2 and total particulate did not reveal a pattern of increased symptoms with higher atmospheric concentrations of these substances. The association of adverse health effects with suspended sulfates was tentatively shown even in communities where existing primary air quality standards for SO_2 and total particulate were met,

There is growing recognition that the existing air quality standard for sulfur dioxide is inadequate, What is needed is formulation of air quality standards for the atmospheric transformation products of SO_2. As a scientific basis for this standard, a better understanding of the atmospheric chemistry of $S0_2$ transformation products is necessary, as is the ability to measure these specific products in the ambient air. Further, the relative toxicities of these transformation products will have to be assessed in order to determine which are more hazardous to health. These findings should be substantiated in systematic human epidemiological studies. These investigations require the ability to generate specific sulfur oxide compounds for study and the ability to measure their concentrations in the ambient air. Finally, it is necessary to elucidate the atmospheric factors that affect the rate of transformation of SO_2 into more biologically reactive compounds.

A concerted research program of health and environmental studies of atmospheric sulfur oxides could produce the basic, though minimum, amount o f health information within three years. The National Academy of Sciences pointed out that "improving the available information about these aspects of sulfur emissions has an expected value on the order of hundreds of millions of dollars a year" (Air Quality and Stationary Source Emission Control, a report by the Commission on Natural Resources, National Academy of Sciences, prepared for the Committee on Public Works, U.S. Senate, Serial No. 94-4, March, 1975, p. xxxvii).

OUTSIDE CRITIQUES

To gain a broader concensus than is achievable by physical panel participation alone, OTA contacted a group of organizations with a request that appropriate personnel review and critique the ERDA-48 volumes I and 11. The list of organizations as shown in Table 1 was chosen to represent both a spectrum of interests and a variety of expertise in the broad subject area, and to complement those capabilities presented on the working panels.

Of those contacted, the organizations marked by asterisk were able to participate. Their contributions follow in alphabetical order by organization, without OTA comment.

TABLE 1
Organizations Contacted for Review of ERDA-48, Volumes I and II

*American Gas Association
1515 Wilson Boulevard
Arlington, Virginia 22209

American Petroleum Institute
1801 K Street, NW.
Washington, D.C. 20006

*American Public Power Assoc.
2500 Virginia Avenue, N.W.
Washington, D.C. 20037

Babcock & Wilcox
Post Office Box 1260
Lynchburg, Virginia 24505

*Building and Construction Trades Dept.
AFL-CIO
815 16th Street, N.W.
Washington, D.C. 20006

Coal Research Bureau
University o! West Virginia
Morgan town. West Virginia 26505

Coal Research Program
Garrett Research & Development Co.
1855 Cassion Road
La Verne, California 91750

(Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095

*Consumer Federation of America
1012 14th Street, N.W.
Washington, D.C. 20004

*Edison Electric Institute
90 Park Avenue
New York, New York 10016

*Environmental Defense Fund
1525 18th Street, N.W.
Washington, D.C. 20036

Environmental Quality Laboratory
California Institute of Technology
Pasadena, California 91109

Geological Society of America
3300 Penrose Place
Boulder. Colorado 80302

Institute for Government Research
University of Arizona
Tucson, Arizona 85721

*Institute of Gas Technology
3423 S. State Street
Chicago, Illinois 60616

Lake Powell Research Project
Dept. of Planetary & Space Sciences
University of California
Los Angeles, California 90024

*National Association of Electric Companies
1140 Connecticut Avenue, N.W.
Suite 1010
Washington, D.C. 20036

National Gas Association
1130 17th Street, N.W.
Washington, D.C. 20036

Scientists' Institute for Public Information
30 East 68th Street
New York, New York 10021

*Sierra Club
Mills Tower
San Francisco, California 94104

United Mine Workers
900 15th Street, N.W.
Washington, D.C. 20005

United Nations Association of the USA
345 E 46th Street
New York, New York 10003

Union of Concerned Scientists
P. C). BOX 289
MIT Branch Station
Cambridge, Massachusetts 02139

AGA American Gas Association

1515 Wilson Boulevard , Arlington. Va 22209
Telephone (703) 5242000

F. Donald Hart
President

July 21, 1975

Mr. Emilio Q. Daddario
Director
Office of Technology Assessment
Congress of the United States
Washington, D. C. 20510

Dear Mr. Daddario:

The American Gas Association, representing over 300 natural gas pipeline and utility companies which serves the public with one-third of its energy needs, appreciates that it was offered the opportunity to review and comment on the first National Energy Plan developed by ERDA. Volumes I and II are very comprehensive documents which reflect the major effort required for their complication.

In view of the thorough treatment given electric and nuclear-electric in Volume I, the Plan, and the draft of Volume II, Program Implementation, we were extremely disappointed that a major energy source like natural gas, upon which this country depends so heavily, has essentially been written off in the long-term. Certainly, enhanced recovery of oil and gas, conversion of coal and oil shale to oil and gas, conversion of waste materials to oil and gas, improving efficiencies in the residential, commercial, and industrial areas, and the use of the fuel cell and solar heating and cooling will provide natural gas and synthetic natural gas for the near and mid-term and extend gaseous fuels into the long-term.

There are two major opportunities to develop gaseous fuels which could easily provide all of the gaseous fuel requirements in the long term and offer a choice of fuels to the American people. In addition to offering a fuel choice,

ATTACHMENT I

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these developments would prevent the wasting of billions of dollars in capital equipment now in place as well as saving the tremendous quantity of energy that would be required to provide other equipment for its replacement.

The first of these opportunities is the production of methane from marine and terrestrial biomass. This can be accomplished by the production of seaweeds, trees, and grasses (which are the most efficient solar converters known) , harvesting and bioconversion of these raw materials to methane. The feasibility of these processes has already been proven. Engineering details must be worked out and proven on the pilot and demonstration plant scales. With the proper effort, this can be accomplished by 1990.

The second major opportunity for gaseous fuel is the hydrogen energy system. Hydrogen can have a major impact as a special purpose fuel, which could lead to a base load energy form in the future. Research is needed in the large scale production (both electrolytic and thermochemical) transmission, storage, distribution and utilization of hydrogen. ERDA should play a major role in this development.

The American Gas Association and its member companies stand ready to cooperate with and assist ERDA in developing and implementing this Energy Plan which is so vital to the well being of this country.

Sincerely,

F. Donald Hart

FDH/sls ,

REVIEW OF

A National Plan for Energy Research, Development and Demonstration

GENERAL COMMENTS

Volume I, The Plan, and the draft of Volume II, Program Implementation, are comprehensive documents which form a good basis for critical review. At the outset, the major criticism and problem with the over–all plan is that it clearly focuses long term wise on electric and nuclear-electric as the only source of energy. This is contradictory to the statement on Page one of the Summary, which states "To overcome this (the energy) problem and to achieve our National policy goals, the Nation must have the flexibility of a broad range of energy choices."

Natural gas and synthetic natural gas are addressed in the near and mid-term priorities, but not comprehensively and clearly not to the extent that electric and nuclear are considered. The production of methane from biomass and hydrogen from water by electrolysis have both been proven feasible. A well–planned, high priority research program could demonstrate both of these technologies in the mid-term and insure all of our gaseous fuel needs for the long-term. Hydrogen is a near perfect fuel which can have a major impact as a special purpose fuel and, in the future, it has the possibility of becoming a base load energy commodity. The Plan should address hydrogen as a separate major subject with the title, "A Hydrogen Energy System." This hydrogen system would include production, storage, transmission, distribution and utilization. We certainly hope that the first revision of the Plan will place natural gas, gas from coal and oil shale, methane from marine and terrestrial biomass and hydrogen from seawater in the proper perspective. The heavy dependence of this Nation on natural gas (provides one-third of all the energy used, over one–half of all industrial energy, and is over 40% of all energy produced in this country) demands that it be placed on the highest priority in all categories.

The Government has done little, if any, research in gaseous fuels (except gas from coal) , particularly in the transmission, distribution and utilization areas. The draft of Volume II of the Plan attempts to address these subjects, but it is obvious that little is known about the problems, research needs, and technical approach. The gas industry would welcome support from ERDA, either separately or cooperatively, in solving these problems. We would also be pleased to discuss the overall situation and to provide recommendations for revision of the Plan and its Implementation.

The American Gas Association and/or its member companies are currently working cooperatively with ERDA on high–Btu gas from coal, hydrogen from coal, methane from marine biomass, enhanced gas recovery, and clean 'boiler fuel. These research areas need expanding and accelerating. Additional research areas for cooperative research between the gas industry and ERDA include, but are not limited to, gas from oil shale; methane from terrestrial biomass; hydrogen from seawater by both electrolysis and thermochemistry; storage, transmission and distribution of gas; improved efficiencies of residential and commercial appliances; improved efficiency of industrial processes; the fuel cell; solar heat and cool; waste heat utilization, etc.

The following are specific comments on Volumes I and II in the order of their presentation.

Volume I
SUMMARY

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1. Figure 2, Page S-2, shows the Remaining Recoverable Projected Domestic Natural Gas Production to be 750 TCF after 1974. The U. S. Geological Survey referred to in the first sentence on Page S–2, states the following:

	237 TCF	Proved
	202 TCF	Inferred
Range	322 – 655 TCF	Undiscovered Recoverable Resources
	761 -1094 TCF	Total Range

If the mean of the Undiscovered Recoverable Resources is calculated, then the above figures become:

237 TCF	Proved
686 TCF	Mean of Undiscovered + Inferred
923 TCF	Remaining Recoverable After 1974

The report should use the Total Range 761 - 1094 TCF or the Mean 923 TCF instead of 750 TCF.

If the Mean is used, then the figures in Figure 2, Page s-2, become:

Old	New
750 TCF	923 TCF
250 TCF	250 TCF
1000 TCF	1173 TCF

2. In Figure 3, Page S-3, shows the Available Energy in 10^{15}Btu) for Gas to be 1030 quads. This is based on the 1000 TCF shown in Figure 2, Page S-2. If the new Mean of 1173 is used instead of 1000, then 1030 quads in Figure 3 becomes 1208 quads.

3. On Page s-4 under "ALL THE NATIONAL ENERGY TECHNOLOGY GOALS MUST BE PURSUED TOGETHER. CONCENTRATION ON ONLY ONE OR A FEW TECHNOLOGICAL AVENUES IS NOT LIKELY TO SOLVE THE ENERGY PROBLEM" a number of strategies are advanced with primary national emphasis in three areas.

We agree that the first primary interest should be reduction of energy waste and inefficiencies.

We agree that the second primary interest should be on the production of synthetic gas from coal and oil shale.

We do not agree that the third should be shifting from gas and petroleum to electricity. We believe that from the Gas Industry point of view the third emphasis should be on the production of methane from marine and land biomass and on the production of hydrogen from seawater by both electrolysis and thermochemical means. The gas industry and its customers have billions of dollars invested in capital plant equipment which must not be wasted. In order to provide the gas industry's customers and the nation with energy at the lowest possible cost demands the development of the inexhaustible resources of methane from biomass and hydrogen from seawater. Therefore, Scenario II on Page S-4 should read, synthetics from coal, oil shale, and biomass consistent with Table 4-3 on Page IV 5, and Scenario III on Page S-5 should be methane from biomass, hydrogen from water, and Improved electrification and Figure 5, Page 3-5 should be changed to be consistent with above.

4. On Page S-6, for the long-term (past 2000), the total emphasis is on nuclear and electricity. The obvious technologies which should be pursued vigorously and which could be demonstrated in the 1985-1990 period, become commercial 1990-2000 and supply huge quantities of energy beyond 2000 are methane produced from both marine and land biomass and hydrogen produced from seawater by electrolysis and/or thermochemical process using nuclear or solar heat. These should also be stated along with the solar electric approach in the "inexhaustible" resource technologies to be given high priority in the fourth item under major changes on Page s-7.

5. Near term efficiency (conservation) technologies in Table 3 should include the Fuel Cell.

6. On Page S-7, Table 5 should include the following:

   1. Materials Research - (Materials (both metals and ceramics) testing, evaluation, data accumulation, and alloy development is urgently needed for construction of coal gasification and liquefaction plants.)

   2. Component Development - (Many components required in commercial scale coal conversion plants have never been designed, built and tested in the very large sizes required.)

7. Page S-8, Implementation of the National Plan, states that, "As a given technology approaches commercialization, the role of the private sector will be paramount" and "Play the major role (financially and technically) in large demonstration and near-commercial projects." Certain segments of industry, such as a regulated industry, cannot raise the required funds or assume the financial risks in the high-risk demonstration and near-commercial plants. The Federal Government must play the lead role and assume the financial risks to demonstrate and prove to industry and the financial community that the very large, high temperature, high pressure systems for the conversion of coal to synthetic natural gas can be built and will operate as designed and produce synthetic gas, interchangeable with natural gas, on a consistent, reliable basis.

8. Figure 2-2, Page II-2, Remaining Recoverable After 1974 should be changed from 750 TCF to 923 TCF and from 1000 TCF to 1173 TCF consistent with 1. above.

9. Table 2-1, Page II-3, Resource Natural Gas, to be consistent with 1. above, change 750 TCF to 923 TCF and 775 quads to 950 quads.

10. Figure 2-3, Page II-4, change 1030 quads of gas to 1208 quads consistent with 2. above.

11. On Page IV-1, change Scenario III to read, methane from biomass, hydrogen from water, and improved electrification, consistent with 3. above.

12. Scenario III, should read methane from biomass, hydrogen from water, and improved electrification consistent with 3. above.

13. Figure 5-1, Page V-2, and Figures 5-2 and 5-3, Page V-3, Figure 5-4, Page V-4, and Figure 5-5, Page V-5, should be changed consistent with 3. above. Also, the text in Chapter V does not include importance of methane from biomass and hydrogen from seawater.

14. Text on Page VI-1, under important near-term areas for conservation should include the fuel cell.

15. Page VI-2, Table 6-1, Goal VI, should include the fuel cell.

16. Page VI–2, Table 6–1, Goal V, Hydrogen in Energy Systems, R, D&D status, should read Lab instead of study. The American Gas Association and others are actively engaged in laboratory investigations of thermochemical cycles for the production of hydrogen, and others are actively engaged in improving electrolytic decomposition of water.

17. Table 6-2, Page VI–3, should be changed consistent with 4. above. Also, text concerning biomass and hydrogen, last paragraph under Developing Other Important Technologies, Page VI-3, should be moved to Page VI–2, Inexhaustible Energy Sources. The production, harvesting and bio–conversion of marine biomass to methane is being actively pursued in both laboratory and deep ocean experiments by the American Gas Association and ERDA. Hydrogen status as in 16. above.

18. Table 6-3, Page VI-4, should include Materials Research and Component Development consistent with 6. above.

19. Page VII-1, Rationale for a Federal Role in R, D&D, should appropriately include the statement that the huge amounts of funds required and the high-risks involved in the development and demonstration of these new technologies involved go far beyond what industry has ever conducted on its own or is capable of doing now and demands major Federal Government support to solve the energy crisis.

20. Page 20, The Private Sector Role, should be changed consistent with 7. above.

21. Page VIII-2, Oil Shale. Limiting oil shale research to In-Situ is not consistent with the major changes described on Page S-7, "Acceleration of commercial capability to extract gaseous and liquid fuels from coal and shale." The development, demonstration, and commercialization of the Hydrogasification of Oil Shale to Oil and Gas can be initiated and completed much more rapidly than In-Situ.

22. Gaseous and Liquid Fuels from Coal. The objective and approach is not consistent with the two–pronged effort described under "Acceleration of Commercial Capability to Extract Gaseous and Liquid Fuels from Coal and Shale," i.e., "Existing technology must be implemented as soon as possible to gain needed experience with large scale synthetic fuel production." Existing commercial coal gasification technology requires design modifications which must be tested and demonstrated in this country on American Coals. This is the

fastest way of obtaining commercial quantities of synthetic gas from coal.

23. **Chapter VIII – Summary of Federal Program Implementation does not, and should, include the production of hydrogen by electrolytic or thermochemical process using nuclear or solar heat. This is a major technology which is not addressed in the Plan and is not consistent with, "... the Nation must have the flexibility of a broad range of energy choices."**

Volume II

The following comments are addressed to the Items indicated and are in the order of presentation in Volume II.

Advanced Research and Supportinq Technology

A research program on testing and evaluation of metals and ceramics is underway. This program should be expanded as rapidly as possible. Special alloy development programs should be initiated as soon as possible.

Second generation commercial coal gasification plants requiring large size, high pressure, high temperature components cannot be built today because these components do not exist. A program must begin immediately to design, build, and test such components.

Demonstration Plants

A goal of one high-Btu gas demonstration plant is insufficient and shortsighted. Every effort should be made to demonstrate on a commercial-size scale all processes that are competitive and successful on the pilot plant scale.

The demonstration plant schedule is far too long based on the critical need for supplemental gas. If the preliminary design step were eliminated and an all-out effort made in detail design and construction, the 10-11 year schedule could be cut to 6-7 years. If internal procedures within ERDA were changed, the time required for proposal evaluation and contracting could be cut from 1-2 years to 3 months.

Competitive proposal procedures is not the optimum proper technique to make this country energy independent in the fastest possible time. Major Government funding of acceptable technical proposals would greatly speed up the process.

Enhanced Oil and Gas Recovery

We are pleased that recognition has been given to stimulation of tight natural gas formations, however, greatly increased levels of expenditures are entirely in order, in view of the natural gas shortage. The Benonian shale forma-

-8-

tion covering bare sections of Appalachia contain reserves surpassing present proven U. S. reserves, however, stimulation techniques must be developed and demonstrated to produce this gas. ERDA support is particularly important as the preponderance of drilling activity in that region is conducted by small companies with limited technology and financial resources. In view of the cost, chance of success, total potential, and time required for commercial adaptation, this is one of the most attractive alternatives available to ERDA.

Coal Gasification

Pipeline Gas

An excellent program which should continue to receive the highest priority. The technological problems are greater than shown in the report. The C F Braun & Co, Technical Evaluation Contractor for the Joint ERDA/A.G.A. Coal Gasification Pilot Plant Research Program issued a report entitled, "Mechanical Development Recommendations for Commercial Scale Coal Gasification Plants" on October 15, 1973 which recommends research required to insure the availability of components and processes for commercial scale coal gasification plants. We recommend that ERDA review and implement this report.

Low Btu Gas

The low Btu gas program appears to be limited to less than 200 Btu/cubic foot for boiler feed. One very large segment requiring tremendous quantities of gas is the lndustrial market which requires gas in the 300-500 Btu/CF range. This subject should be addressed as a separate and distinct problem.

In-Situ Gasification

We recommend that ERDA fund the Lawrence Livermore Laboratory in-situ coal gasification process to determine the technical and economic feasibility of the process and to demonstrate it on a commercial scale if successful. This process can produce pipeline quality gas which is so urgently needed.

Oil Shale

Limiting oil shale research in the plan to In-Situ is not consistent with the major changes described on Page 3-7 in the plan Summary, "Acceleration of commercial capability to extract gaseous and liquid fuels from coal and shale." Above ground retorting needs research. The development, demonstration, and commercialization of the Hydrogasification of Oil Shale to Oil and Gas can be completed within the near term. In-Situ, if ever successful, will require many years.

Fuels From Biomass

The marine biomass, which is the most efficient solar converter, can proceed at least as rapidly, if not faster, than terrestrial biomass with the proper support from ERDA. A 7-acre experimental farm just off San Clemente Island 60 miles west of San Diego has already proven that giant California kelp can be transplanted, grown, and reproduced on an anchored structure made of polypropylene rope at a depth of 40 feet in 350 feet of water. In addition, juvenile kelp has been successfully grown in the laboratory in water obtained from 1000 feet in the deep ocean. The California kelp is harvested commercially by specially designed ships, such as the Kelco Co. in San Diego. The kelp will produce methane naturally when out of water, and methane has been successfully produced in the laboratory from this kelp. With proper ERDA support, this process can be engineered through the pilot and demonstration phases very rapidly. Given appropriate attention and priority, we believe that the marine farm concept can fulfill all of our gaseous energy requirements in the future.

Solar Heating and Cooling

Since low cost, high reliability and long life solar components do not exist, the major emphasis should be placed on their development in the shortest period of time instead of demonstration of components which will not fulfill the need.

Technology Utilization and Information Dissemination

One of the problems associated with information dissemination which was not mentioned is inherently associated with the development of hardware by potential solar energy-related equipment suppliers. Proprietary positions will be sought which will delay dissemination of new information. Elimination of the proprietary positions will slow the development of hardware.

Conservation in Buildings and Consumer Products

Objectives

Under near term to 1985, a 20% reduction in energy consumption in existing buildings is the goal, and a 30% reduction in new buildings. There is no base structure defined which is to be modified for the consumption reduction. One might assume that the base case is the "state–of-the-art" building envelope.

A major effort has been made by ASHRAE in development of Standard 90. If this Standard is implemented by legislative action, the 30% reduction in energy consumption might be demonstrated daily. This amplifies the need for a typical base case. The magnitude of the technological challenge is not apparent in the objectives due to rapidly changing building practices.

Community Systems

Problems

The first technological problem listed is the development of more efficient components, subsystems, and total systems which utilize fuels other than natural gas and fuel oil. While this may represent specific fuel preservation, it might not necessarily promote energy conservation.

Consumer Products

The American Gas Association has been conducting research in improving the efficiencies of all types of residential and commercial appliances for many years. We would appreciate the opportunity to discuss this entire subject with ERDA personnel and assist by providing material for preparation of the next Plan and cooperate in the Plan's implementation.

Energy Storage

For some mysterious reason under Wind Energy Conversion, the plan suggests electrolyzing water to produce hydrogen for on-site fertilizer manufacturing. In this Energy Storage section, the plan is to develop hydride and other hydrogen storage devices. In another section a Hydrogen Energy System is mentioned but not defined and implemented.

Hydrogen is a near perfect fuel which can have a major impact as a special purpose fuel and in the future it has the possibility of becoming a base load energy commodity. The first major problem is the economical production of hydrogen on a large scale. Two methods for this production, electrolysis and thermochemical, have been proposed. Hydrogen production by these technologies could utilize either nuclear or solar heat or electricity. Both should be vigorously pursued. The plan does not address this problem. Further, the plan does not consider a hydrogen energy system of the future involving production, transmission, storage, distribution, and utilization. This should be a major section in the next plan.

Industrial Energy Efficiency

The American Gas Association has been making studies and performing experimental projects on a commercial scale for several years on improving industrial process efficiencies. We would welcome the cooperative support of ERDA. We urge cooperative implementation of projects in the next Plan.

Building and Construction Trades Department

AMERICAN FEDERATION OF LABOR — CONGRESS OF INDUSTRIAL ORGANIZATIONS

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Action AC

Info EQD
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August 12, 1975

Rec'd 8/20
Preparation of reply
for sig of
Action #
Suspense

Mr. Emilio Q. Daddario
Director
Office of Technology Assessment
U. S. Congress
Washington, D. C. 20510

Dear Mr. Daddario:

In response to your invitation of June 23, I would like to take this opportunity to convey the views of the Building and Construction Trades Department, AFL-CIO regarding ERDA's National Plan for Energy Research, Development and Demonstration.

The Building Trades Department, representing 17 affiliated international unions and 3 1/2 million workers, has taken a vital interest in energy-related matters. The energy crisis is not only a crisis for our members in their roles as consumers, but it is also a crisis for them as workers. It is for this reason that the Building Trades is pleased to have this opportunity to offer its comments on ERDA's comprehensive assessment of this country's energy situation.

From the standpoint of the Building Trades, ERDA's mixed strategy of necessary options is a realistic and practical evaluation of our worsening energy situation. We have long been on record in support of increasing our energy supplies, particularly through the increased utilization of coal and nuclear energy, while at the same time conserving our energy resources. ERDA's national plan presents a balanced strategy encompassing this approach.

At the suggestion of your office, the Building Trades would like to briefly comment on one of several potential constraints of implementation identified in your report, namely, manpower.

It is true that the proportion of construction labor presently employed for the erection of energy-related facilities is a small fraction of the total work force. It is also true that over the next decade this proportion will rise only slightly. Nevertheless, we must insure against manpower difficulties arising in the course of providing badly needed energy-supply facilities.

As stated in ERDA's report, reliance upon natural market forces to balance the demand and supply of labor is generally a safe strategy. We can count among our 17 affiliated internationals some of this country's best manpower training programs. This factor, coupled with "the dynamic character and mobility of the labor force . . . [A]nd the lead time anticipated by the Plan" should minimize large-scale problems.

However, it is conceivable that regional and local labor force imbalances might develop. The labor requirements for energy facilities are rapidly escalating. Our estimates now show that each 1000 megawatt nuclear plant alone requires a peak construction site work force of 2,000 to 3,000 workers. Because of the large component of skilled labor required of these projects, certain areas of the country might have labor shortfalls.

The trend towards energy parks and more isolated sites in power plant siting will only compound these difficulties.

We view these shortages as unnecessary. With the proper planning and forecasting, the industry and the building trades in particular, would be more than able to supply any manpower needs. We would like to suggest that the possibility be explored of developing regional information systems on impending construction. Knowledge of a region's construction schedule would enable local unions to gauge their apprenticeship programs to expected demand. We don't want to see our unions involved in training programs created in the wake of energy hysteria which are unnecessary and superfluous.

The chief obstacle to compiling such a system will be the fact that manpower demand in a region will not simply be a function of upcoming energy projects; it will be a function of all construction. Any information system will have to take account of the region's entire construction schedule.

Finally, the Building Trades Department suggests that implementation of any activities designed to meet projected manpower requirements include close consultation with the Building Trades. ERDA's description of its manpower development program makes no mention of the allied building trades. Yet, it is these trades in conjunction with contractors and private sector employers who have spearheaded our industry's various training programs. We regard this as a serious omission.

In closing, the Building Trades Department wishes to commend ERDA on its National Plan. Hopefully, the Plan is truly a blueprint for our future energy well-being.

With best wishes, I am

Sincerely,

Robert A. Georgine
President

RAG/lr

energy policy task force

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LEE C. WHITE, CHAIRMAN ELLEN BERMAN DIRECTOR

Action JV
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July 22, 1975

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Preparation of reply
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Action #
Suspense

Mr. Emilio Q. Daddario
Director
Office of Technology Assessment
Senate Annex, 119 D Street, NE
Washington, D. C. 20510

Dear Mr. Daddario:

1 have had a chance to review briefly the recent Energy Research and Development Administration report, and have some comments that I hope will be helpful. Although it is obviously an ambitious effort, it does not adequately encompass several important issues. Recognizing the inherent difficulties in developing a comprehensive and positive energy program, Congress authorized ERDA to survey the country's needs and problems. The recently released report details many of the numerous difficulties which lie ahead. The stated solutions, however, merely reinforce our deepest concerns without necessarily providing a direction or, for that matter, much hope.

Reflecting the residual influence of the old Atomic Energy Commission, ERDA emphasizes nuclear reactors and describes high hopes for fast-breeder reactors. However, the same pages containing these aspirations bear disclaimers that reactors are terribly intricate and cannot possibly be completed until the next century. Nevertheless, the money recommended for atomic research is astronomically larger than the amount designated for solar energy research, perhaps the most available, safest way to solve our energy problems. There is nothing necessarily wrong with this, but one gets the uncomfortable feeling that we are not pursuing alternatives at a lusty enough level.

In addition, "environmental restraints" on the potentially hazardous nuclear energy development are only mentioned in oblique, muted terms. Although our national security and environmental health might be at stake as this research develops, ERDA did not find it necessary to outline precautions. It is nearly inconceivable that the authors of the ERDA report would believe any new energy research should go forward without due concern for necessary precautions and environmental safeguards.

consumer federation of america

ATTACHMENT I

Mr. Emilio Q. Daddario
July 22, 1975
Page Two

Perhaps such oversights--if they are oversights--could be prevented if consumer-oriented non-governmental advisors were added to ERDA advisory committees. These programs affect us all, and there should be a corresponding broad representation in the advice received by ERDA. And after research is started--nuclear and otherwise--progress reports should be presented to Congress and to a citizen-oversight committee on a regular basis. No such reporting mechanism is detailed in the ERDA report, although it is of considerable importance.

The authors of the ERDA report have only discussed the use of waste materials in terms of environmental control. In fact, the actual conversion of waste material, including everyday garbage, may provide a valuable energy resource. This omission may be another indication of the authors' bias towards centering energy and energy-related research around nuclear development.

The ERDA report explains that the development of new resources will be shared by both the public and private sectors. However, there is no explanation of the turnover from the government to industry or for the sharing of original costs. There is no explanation of who will do original research. No mention is found in the report's pages of the need for competition in the research and development aspects of new energy resources and equipment. Obviously, such questions must be answered before any plans for development can be taken seriously.

The task before us is not easy. The establishment of ERDA and its efforts to map out our future energy needs and programs are basically encouraging. We hope, however, that some of the above suggestions will be helpful.

Thank you for the opportunity to comment.

Sincerely,

Lee C. White

NATIONAL ASSOCIATION OF ELECTRIC COMPANIES
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WASHINGTON. D. C. 20036

DAVID R TOLL
MANAGING DIRECTOR
AND
GENERAL COUNSEL

2021223.3460

July 22, 1975

Mr. Emllio Q. Daddario
Director
Office of Technology Assessment
Washington, D.C. 20510

Dear Mr. Daddario:

Thank you for your letter of June 23, addressed to Mr. Guy Nichols, Chairman of this Association.

We appreciate your invitation to critique the two volumes relating to ERDA's National Plan for Energy Research, Development and Demonstration.

To present a composite commentary from investor-owned utilities, we have prepared our comments in collaboration with the Edison Electric Institute in New York City. Their critique does include our comments and should be received by you shortly.

Sincerely,

David R. Toll

David R. Toll

Action JV
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Rec'd 7/24
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EDISON ELECTRIC INSTITUTE
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July 24, 1975

Mr Emilio Q Daddario
Director, Office of Technology Assessment
Congress of the United States
Washington, D C 20510

Dear Mr Daddario

Thank you for your June 23, 1975 letter which provided the Edison Electric Institute with the opportunity to submit comments to the Office of Technology Assessment on ERDA's Energy Research, Development & Demonstration plans and programs. As the principal association of the nation's investor-owned electric utility companies, EEI is vitally concerned with steps taken by the Federal government to advance the technology that will insure an adequate supply of energy for the United States in the years ahead.

We note that the objective of the review that OTA will submit to the House Committee on Science and Technology, the Senate Committee on Interior and Insular Affairs and the Joint Committee on Atomic Energy is to "identify and discuss those questions concerning the programs presented by ERDA that are critical for Congressional attention because they represent unresolved, controversial, or overlooked areas." Our analysis of the two ERDA documents has been from this point of view. We find that while the overall ERDA outline is, for the most part, complete and comprehensive, in certain critical respects relating to the science of generating, transmitting and distributing electricity, it is unbalanced, out-of-focus and inadequate. EEI welcomes the opportunity to have its views on these crucial weaknesses included in the OTA review that will be called to the attention of key legislative bodies.

EEI commends ERDA for its comprehensive analysis of the country's energy situation and outlook that has resulted in the "National Plan for Energy Research, Development & Demonstration: Creating Energy Choices for the Future." The significance of this undertaking is even more noteworthy in view of the fact that it has been formulated in the absence of a strong, coherent national energy policy. In lieu of such basic policy, we endorse the soundness of the five "national policy goals" used as a focus for the ERDA program.

We also support ERDA's intention of insuring that its national energy RD&D plan is kept responsive to changing needs and conditions. This would be done by periodic up-dating of the initial plan. We take this occasion to suggest that through the Electric Power Research Institute an electric utility industry advisory group of high technical management level representatives be organized to work with ERDA on a continuing basis. Similar groups from other industries may also be of assistance. Without strong and active industry involvement, technology assessments and planning guides will tend to be out of touch with reality.

EEI does not agree with the general tone of ERDA's Volume I in one important respect. While recognizing the country's need for Liquid Metal Fast Breeder Reactor (LMFBR) technology to permit the use of an essentially inexhaustible resource, ERDA appears to de-emphasize the priority assigned to the development of this concept. Chapter VI of Volume I classifies the LMFBR concept along with solar-electric generation and controlled nuclear fusion as technologies whose potential contribution to the nation's energy supply will occur in the year 2000 and beyond. The prospect for the LMFBR is underestimated. ERDA's Experimental Breeder Reactor II has logged more than ten years of successful operation, and breeder reactor technology is clearly established.

As the Edison Electric Institute has pointed out repeatedly before Congressional committees and other government bodies, there is no single energy related research effort that holds greater promise for insuring adequate reliable electricity supply for the American public than the breeder reactor program. The importance the electric utility industry attaches to development of the breeder is reflected in its commitment to contribute nearly $260 million to the Clinch River Breeder Reactor demonstration plant project. This is the largest contribution to a single R&D project ever made by the industry. Solar-electric and fusion research should be accelerated to the extent that funding can be used effectively. It would be a serious mistake, however, to do this by slowing down development of the LMFBR and delaying the date at which this option becomes available.

Another specific comment relates to the method selected by ERDA in Volume I to yield its conclusion that to meet the country's needs, research effort must be directed at a combination of technologies rather than toward a specific area. This conclusion is reached by selecting six contrasting national energy "strategies" or "scenarios" -- some of which are assumed to have an "unrealistically high degree of success." By analyzing the net imports of oil and gas required by each of these scenarios to the year 2000 in this "paper and pencil experiment," the "Combination of all Technologies" scenario is found to be superior.

Although the rationale for the selection of this methodology is not entirely clear, the ERDA conclusion that technology should be attacked on all promising fronts is reasonable. EEI takes exception, however, to Scenario III which is the "Intensive Electrification" case. Scenario III examines how "the total energy picture would be affected by an intensive shift to electrification, with (1) maximum use of all sources to generate electric power and (2) maximum reliance on electricity for end-uses." With certain assumptions included, although basic data are lacking, the results of this scenario are shown to be less desirable in terms of net imports of oil and gas in the year 2000 than do all other cases with the exception of the "No New Initiatives" scenario. To suggest that it is undesirable to move toward greater electrification, based on indigenous fuel reserves, is inconsistent with achievement of the country's energy goals.

Not only is the scenario method of analysis open to question, its implied and stated conclusions relative to the future role of electricity in the country's energy picture is unwarranted. In a conservation oriented and environmentally conscious society, electricity will be substituted increasingly for end-use energy purposes. Expanded electric power grids will improve the efficiency of our energy transportation system.

A final comment is concerned with the discussion in Chapter VII of Volume I dealing with the responsibility of industry in achieving national RD&D goals. The recent organization of the Electric Power Research Institute stands as evidence of the electric utility industry's recognition of the important part it has to play in this government-industry cooperative effort. Investor-owned electric utility companies will continue to meet this vital responsibility. The industry agrees with ERDA that the "private sector" should "Interact strongly with the Federal government in developing the economic, technical, safety, and environmental aspects of the National Plan for Energy RD&D." EEI points out, however, that while on occasion, as stated in the ERDA Volume I, industry should "Play the major role (financially and technically) in large demonstration and near-commercial projects," there are instances when the cost of a technically advanced demonstration plant will extend beyond the ability of an industry. In these instances, such as the Clinch River Breeder Reactor plant, the Federal government appropriately should provide financial assistance that will make the R&D results available to assist in meeting the needs of the public.

Sincerely yours

W Donham Crawford

W Donham Crawford
President

cc: Messrs S L Sibley
F W Lewis
Chauncey Starr

ENVIRONMENTAL DEFENSE FUND

162 OLD TOWN ROAD, EAST SETAUKET, N.Y. 11 733/516 751-5191

July 17, 1975

Mr. Patrick Gaganidze
Congress of the United States
Office of Technology Assessment
Washington, D. C. 20510

Dear Mr. Gaganidze:

Enclosed is a copy of my critique of the ERDA National Plan. I trust it will be of assistance to you, your fellow staff members and the Congress. Please feel free to call me should you have any questions regarding my comments.

Thank you very much for permitting us the opportunity to comment on ERDA's activities. I am

Very truly yours,

Ernst R. Habicht, Jr., Ph.D.
Staff Scientist and Director
EDF Energy Program

Enclosure

OFFICES IN: EAST SETAUKET, NY (MAIN OFFICE); NEW YORK CITY (PROGRAM SUPPORT OFFICE); WASHINGTON, DC; BERKELEY, CALIF.; DENVER, COL.

8

July 17, 1975

Comments of Ernst R. Habicht, Jr.
Staff Scientist and Director, EDF Encrgy Program
Environmental Defense Fund, Inc.
162 Old Town Road
East Setauket, Ncw York 11733

To: The Office of Scicnce Technology, U.S. Congress

Re: ERDA 48; A National Plan For Energy Research, Devclopment and Dcmonstration*:

GENERAL OBSERVATIONS

Since the research and development activities of today are likely to provide the basis for commercial technologies some twenty to thirty years from now, one needs to make a number of educated guesses regarding plausible scenarios for **U.S.** and world energy markets. Of no less importance is that, with rare exceptions, the individuals who devise and advise the creation of such documents as the National Plan (see also AEC Chairman Ray's Report to President Nixon in December of 1973) arc uniformly imbued with the spirit of past technological advances and, despite recent strong evidence to the contrary, are still possessed of an expectation of ever-lower energy costs, at least in the long run. .

Thus it is not surprising that the National Plan appears as if it had been written prior to the late 1960's by the AEC for the Joint Committee on Atomic Energy.

Familiarity with the electrical utility sectors in the United States leads one to several conclusions:

1. Even absent fuel price increases, electricity supply has encountered absolute diseconomics of scale in generation which began to become perceptible in the mid to late 1960's;

2. Continued investment in central electric generation technology is becoming increasingly unfavorable with respect to the alternative of investments in partially electricity-dependent, integrated technologies at or near the site of end-use; and

* Hereinafter referred to as the "National Plan."

3. From the perspective of the economist, the consumer or the envirommentalist, the way electricity is priced has become increasingly irrational in recent years.

From this set of perceptions regarding electricity supply, I conclude that the Natioal Plan is most deficient in that it is moot On recent abrupt departures from past experience and ignores the impact of institutional change within society on the technology required in future years. Thus the National Plan focuses most heavily on large centralized fuel processing and energy conversion facilities that accord most closely with an extrapolation of today's energy technologies. Present and growing countervailing trends in the U, S. energy economy render such an emphasis on centralized supply and conversion technology misdirected in some instances and counterproductive in others. An incomplete list of such countervailing trends follows:

1. Over 50% of the energy in the U.S. economy is directly regulated at the state level as to price. Under far more pressure by consumers than ERDA, state regulators are becoming increasingly sensitive to the advice of economists most particularly with respect to the wisdom of employing marginal cost pricing for electricity. This will stimulate decentralized storage, integrated electric/solar space conditioning, and, in some instances, integrated elctric/fossil fuel systems.

2. Present federal and state tax law is written in accord with the perception that energy costs will fall overtime. Also, buttressed by freight rates and numerous other regulatory policies, the tax laws discriminate strongly in favor of primary materials in the U. S. economy as opposed to recycled materials. It is reasonable to expect that there will be an increascd need for superior recycling technologies including those directcd towards the manufacturing of goods in such a way that the composite materials may be more easily returned to material flows in the economy.

3. Our high agricultural productivity depends upon centralized inputs of large amounts of energy in the form of fuel, fertilizer, pesticides, food processing and transport, Little if anything in the pronouncements of the USDA in recent years would lead one to believe that there is any concern about the energy intensity of agriculture in the U.S. economy. Indeed, the overwhelming majority of federally-funded agricultural research is directed towards increasing the centralization of agricultural processes with concomitantly increased energy intensity of production. Sustained high agricultural yield, together with rcduced energy intensity in our agricultural economy would seem to be a laudable research, development and demonstration goal. Given the present structure and goals of the USDA, one should not be optimistic about conducting solar or other energy R, D & D within or in collaboration with that agency.

4. At present, the most critical energy sector in the U.S. economy is natural gas. Great emphasis is placed on increasing gas supplies through coal gasification. Present exceptionally expensive commercial endeavors directed towards this end (and all the ERDA studies with which I am familiar), have neglected an attractive alternative to be taken over the next five years. This involves the production of low heat content gas which, pursuant to modification of present large "gas-fired boilers, would be "swapped" for that substantial portion of natural gas now committed to the production of process steam and electricity. Customers who are being curtailed are also an attractive near-term target for this technology especially if they would normally switch to oil firing. To explain this in greater detail I am attaching the comments of the Environmental Defense Fund on the Draft Environmental Impact Statements for both the El Paso and the WESCO coal gasification projects. The reader is a1s. rcfcrrcd to the El Paso case before the Fcdcra1 Power Commission (Docket No. CP 73-131).

TIMING AND WORLD ENERGY RESERVES

While assuming that it is a laudable goal to become largely or entirely free of imported energy resources, the National Plan seemingly neglects arguments against such a policy and contains no useful discussion regarding the transition years during which, under any possible scenario, we will continue to be dependent upon imported oil and to a lesser extent, imported natural gas. Quite clearly, any rational U.S. energy program need consider the merits and costs of an oil storage system; indeed, Congress has already authorized a meaningful step towards such security. A research, development and demonstration program should be directed towards the speedy testing and implementation of some of the concepts for oil storage that have been advanced thus far. (See, for example, The Oil Security System by Daniel H. Newlon and Norman V. Brekner, Lexington Books, Lexington, Massachusetts, 1975.)

Since the world oil market has become an evermore important determinant of the U.S. energy market, it seems foolish for ERDA to posit a research and development program without any discussion of what is going on in the rest of the world. We are presently in the midst of a growing world oil glut. Many astute observers of international oil markets are convinced that the OPEC cartel will soon begin to lose strength and oil prices will fall sharply. One plausible scenario for the future is declining world energy prices in the near term and increasing prices after another ten to fifteen years -- when the world's oil production and reserve data look like those of the U. S. today. This indeed compounds the dilemma of policy makers here in the United Stales. But, since credibility with the general public can only be viewed as a virtue (and this seems especially so today), this scenario should be more amply discussed.

Many of the actions wc would take in a "crash program" directed towards self sufficiency would lead this country to greater energy intensity in the short run (via direct inefficiencies in energy use and the adverse near term]mt-energy consequences of rapidly changing conversion and end use technology). Continued reliance on imported fuels over the next ten years or so is desirablaeif we take adequate steps to protect ourselves against disruptions in supply. The more time that can be bought through energy conversion and efficiency improvemcnts, the better. But it is really the long run expectation that looms over the substantial bulk of the ERDA National Plan since the payoff from new energy supply research, development and demonstration does not really be@ to have much effect until 1995 or so. At our present level of knowledge about world oil reserves, this turns out to be the period when wc can reasonably expect the cost of oil to be relatively high and the price to be on a definite upward trend. By that time, assuming our efforts have been successful over the preceding 20 years, we will be in an excellent position to market technologies to other nations. This might be compared to our present dependence on German coal gasification technology that was brought into commercial.ization during the second World War.

While specific programs pertaining to energy supplied from both old conventional and new exotic sources is discussed on a sector by sector basis below, some of the present emphasis of the National Plan is commendable and in accord with the scenario laid out immediately above. I agree wholeheartedly with the concept that the most fruitful area of energy R & D in the relatively near term is to improve the efficiency of energy use everywhere in the U.S. economy from the point of extraction to the point of end usc. Towards such ends, the endeavors of social scientists should be emphasized heavily. Since future energy technologies (to be developed and demonstrated by the year 2000) can be reasonably expected to be more expensive than today's technologies, the continued endeavors of such research programs over the life of ERDA seem highly justified.

At every stage of ERDA efforts, unbiased and economically disinterested technical review deserves a high priority. Attached is the testimony of EDF witness Dr. Robert J. Budnitz in Application No. 54279 before the California Public Utilities Commission. Dr.. Budnitz places considerable emphasis on the need for public scrutiny of R & D budgets, (in this case, that of the Pacific Gas and Electric Company by the public and independent agencics. Dr. Budnitz also speaks strongly to the need for research on the general question of energy demands -- a subject touched upon in the preceeding paragraph above.

ENERGY SUPPLY SECTORS

1. Nuclear Fission. This reviewer strongly supports the position of the Natural Resources Defense Council and affiliated parties in their opposition to speedy implementation of the liquid metal fast breeder reactor program. The work of Dr. Thomas Cochran at NRDC and formerly at Resources for the Future is definitive in providing irrefutable economic and technical criticism of the ERDA breeder program. Energy R & D ought to focus most heavily on implementation of technologies whose end results afford a minimum array of irreversible consequences and intertemporal inequities. For this reason, if for no other, "bypassing the breeder" is a laudable goal. While this priority may be less indicated in the future as *a* result of significant technological change, the ERDA budget is badly skewed towards a program that offers speedy implementation of a technology whose consequences are profound in terms of uncertainties, risks, unknowns, intertemporal inequities and irreversibilities. The decision rules employed by the NRC and ERDA deserve the closest possible scrutiny and criticism. To this end and by way of specific example, I am attaching a copy of a paper by Professor Paul L. Joskow entitled "Approving Nuclear Power Plants: Scientific Decision Making or Administrative Charade?" (The Bell Journal of Economics and Management Science, Vol. 5, No. 1, Spring 1974, at page 320).

2. coal. I am concerned about heavy emphasis on centralized federal research in the domains of coal mining, handling, cleaning and conversion technology. The coal industry has a sorry record for research and development over its long history in the United States -- to be contrasted sharply with the joint government-industry endeavors that have been encouraged in Englnd and Germany. With the possible exception of the Consolidation Coal Company, no significant amount of innovation has come forth from the domestic coal industry. In order to get new technologies that are more bcnign to the coal miner, the coal environment and the coal consume, the industry itself is going to have to undertake and participate intimately in all phases of research, development and demonstration. The attitudes of coal managers, mining engineers and miners themselves are going to have to change if this industry is ever to lift itself abovc the past tradition of boom and bust with no thought for the future and a fondness for the past.

A national severance tax on coal directed towards R & D to revert only to those mining firms who actively engage in R & D seems to be a warranted institutional prod in the right direction. This should accompany a tough surface mine reclamation statute that is also directed towards abating the externalities associated with deep mining. Such a statute would, once and for all, relieve the coal industry of an enormous barrier of uncertainty associated with future mining development. Entry into the industry 'should be encouraged through a progam of integrated federal leasing policy, business loan policy and federal agency contract purchases of coal.

3. Oil and Cas. The petroleum industry substantially retrenched its energy research and development efforts starting in the latter part of the 1960's. Laboratories were closed, consolidated or dedicated to more routine purposes and skilled personnel were transferred out of research endeavors, retired early or fired. By having ERDA involve itself in activities that would normally be undertaken by the industry itself, we have a hefty increase in taxpayers subsidy of petroleum exploration, production and consumption. This is particularly so in view of the very low domestic tax rate that is effectively applied to the major petroleum producers.

The only seeming justification for government involvement in enhanced gas and oil recovery is institutional. For example, individual oil reservoirs behave quite differently under varying secondary and tertiary recovery approaches. Thus ERDA may be prompted to be involved in such experimentation so as to speed the transfer of technology from the oil fields of one company to those of a second company and thus avoid anti-trust complications. This may wcll duplicate information exchanged in joint ventures beyond the continenta1 boundaries of the United States. Rcgardless of whether or not such information cxchange takes place between individual fires, ERDA emphasis on this particular set of endcavors seems to be one more nail in the coffin of the idea that wc have a competitive oil industry here in the United States.

4. Solar. While considerable work needs to be performed to make direct solar space cooling technology dependably competitive, solar space heating technology is now being implemented by the private sector and production technologies for solar collectors are presently available for mass production. The principal barriers to

implementing solar water and space heating technology would seem to be institutional in nature. Questions of financing (life cycle costing) and constructing (in a depressed, fragmented and under-capjtalizccl construction industry) seem to be of prime importance. Some of 13 RDA's "demonstration projects" manage to be counterproductive in that the relatively slow-to-move financial and construction industries may continue to wait for "the last word" from federally financed demonstration developments. The entire ERDA solar space conditioning budget might be more favorably applied to the removal of institutional and lcgal constraints at the federal, state and local level. A combination of small business loans to contractors, federal housing financing incentives and even tax incentives might provide the necessary push and pull to achieve more rapid commercialization.

Virtually all of the solar electric dollars seem to be directed towards central utility concepts. A large portion of the costs of solar elcctric technologies are in the physical apparatus required for the collection of the sun's energy. This is essentially a "two-dimensional" technology and may not properly be expected to admit of great on-site economies of scale with increasing deployment. Of course, substantial technological change is needed to render any of the proposed solar electric technologies competitively viable.

It would seem that more attention might be paid to future establishment of small scale solar electric technologies intended for the customers side of the meter where the diseconomies of scale of small storage units is offset by reduced transmission and distribution requirements. As noted earlier with respect to conventional electricity investment today, there is the greatest promise for small scale technologies. This would include the load management and pricing reforms discussed earlier as well as the promise of dispersed technologies such as fuel cells -- which can be sited quite close to modcst demand centers thus avoiding transmission cost-s.

5. Conservation. Most of the goals in this gcncral category are certainly laudable but will probably be achieved quite speedily through normal market forces and good flow Of' information, A principal government role ought to be the wide promulgation of developments concerning encrgy conservation so that managers, engineers, the press and hence consumers can take cffective action all thc more quickly.

There is little sense of priority in each of the separate conservation categories and thus the ERDA program is made all the more fuzzy. Some of the proposed research is worded in such a way as to be directly counterproductive to the avowed goals of the program. For example, the statement regardeing institutional problems concerning air transport which reads: "Federal regulations on safety, noise and emissions need to be reexamined to reflect strengthened fuel conservation policy. " (Vol. 2 at p. 79) is almost certainly a direct reflection of the DOT, CAB, FAA and State Department position in favor of the Frcnch/British SST. As such, it could not be more counterproductive with respect to energy conservation. In this same section of institutional problems associated with air transport, no mention is made of attempting to directly increase load factors or to minimize problems that ensue from the control of airline regulation by the industry itself.

In such "institutional problem" areas ERDA is stepping on sensitive political ground. If we really wanted to improve transportation efficiency, we would pay close attention to the advice of economists who advocate that user charges reflecting total marginal social costs be imposed upon each transportation mode. Thus, commuter traffic would begin to pay a formidable price for using crowded highways. There would begin to be meaningful user charges for trucks which more accurately reflected the maintenance requirements occasioned by their use of highways. Barges would, for the first time, begin to pay a user charge. The conventional wisdom of the ICC would wither and with its disappearance would return the health of the railways. Such a list is nearly endless.

The point to remember here is that ERDA may, by virtue of its working solely within the existing framework, perpetuate and compound inefficiencies and idiocies that presently obtain. If it is to involve itself in institutional problems, then let such involvement be wholehearted. Such a step proved impossible to the AEC whose failure in this area led to tjr formation of the NRC and ERDA. This implies the need for continued funding of institutionally directed R and D activities by other agencies such as the National Scicnce Foundation.

6. Manpower Training. Where possible, programs should be initiated to provide reeducation of unemployed and under-employed technical personnel. At a fairly high level, the Miami University Medical School Program in Florida, directed towards re-education of scientists in a considerably accelerated M. D. program, stands as a good example. The field of mining engineering would certainly benefit by an infusion of such new talent.

THE ERDA APPROACH TO R & D

It would be nice; to imagine an agency of five or six thousand people directed towards research and development avoiding the past mistakes of the AEC. This may be difficult since ERDA is so heavily dominated by personnel who have been transferred from the AEC. Serious questions need to be raised rcgarding the decision making apparatus and speed of action within the agency regarding new policy and technologies.

Every effort must be made to pare down the number of level.s of decision making within the agency. ERDA must pay attention to ideas as opposed to “proposals” so that the agency gets behind innovative thinking at an early stage and avoids outright intellectual dishonesty. Nothing is worse than the consequences of establisling just another federal granting “old boy” network wherein new fresh talent is effectively shut out of timely funding. Yet there is no inclination that a fresh approach has been made.

Stale corporate proposals placed before ERDA seem to be funded with regularity. Some of these comprise efforts that would be normally undertaken by the industry in question absent any federal funding whatsoever. Some redundancy is evident. individuals and small groups with good ideas are heard to complain that they have difficulty talking to anyone who can make a decision at the agency. There seem to be too many layers of review wiithin ERDA and action seemingly takes forever. Only the large entrenched powerful interests in the U.S. economy can long withstand such an approach to R & D funding. Small enterprises and entreprenual ventures wither away and good academic research by bright young investigators simply never is performed. This is another argument for funding of energy research and development by other smaller federal agencies such as NSF as well as for sweeping review of ERDA policy by disinterested experts.

Whether or not ERDA is merely to be the handmaiden of entrenched industrial ventures (and the foe of new industrial interests), the question of how it is funded ought to be addressed directly and soon. Every dollar of the taxpayers money that goes into ERDA represents a transfer of taxpayer dollars into the consuming cnergy sector. Thus we are subsidizing energy consumption out of general tax revenues. As ERDA and similar agencies grow, this problem will become more severe. The history of the AEC is rife with examples of such subsidies and it is of no use to repeat the litany of criticism here. Instead, the reader is *referred to the* Book of Prophets: *Chapter* 26, Verse 11.

IGT

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July 21, 1975

Mr. Emilio Q. Daddario
Director, Office of Technology
Assessment
Washington, D.C. 20510

Dear Mr. Daddario:

The Institute of Gas Technology appreciates the opportunity to review the "National Plan for Energy Research, Development and Demonstration" developed by ERDA. We hope the appended comments can be of help to you.

As one of the nation's major energy research organizations working both for the government and industry, we believe that this is a document of major importance. It should receive constructive inputs from all sectors of the nation.

To this end Dr. Derek Gregory, the IGT staff and I have given the document a very serious review. We hope to be able to serve a similar role in the future.

Very truly yours,

Jack Huebler
Senior Vice President

JH/klf

Action JV

Info EQD w/o
DVD encl.
LD

Rec'd 7/21
Preparation of reply
for sig of
Action #
Suspense

REVIEW OF "A NATIONAL PLAN FOR ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION"

Overall Comments

The document is comprehensive and intelligently put together. There is an excellent summary from which one can extract national policy goals, national energy technology goals and priorities for developing technologiess. Some qualifying statements about the present shortcomings of the plan itself are given near the end of Vol. 1. A concisely expressed statement of the National Energy Plan placed at or near the beginning might be helpful.

The report has a heavy bias towards nuclear energy and electric power. This is not so much in the recommendations but in the examples that are drawn, the scenarios chosen and the more detailed discussion of particular technologies. We would hope that forthcoming revisions could amend this weakness. The report was probably put together primarily from people with an AEC background, and their previous environment shows through in the way they express themselves. It is especially disturbing to find the emphasis on the opinion that the inexhaustible energy sources, breeder, fusion, and solar electric, could only be used to produce electricity, and therefore there was a need for the development of electrification techniques. This opinion is expressed 4 or 5 times throughout the report. In the same vein, while one of the inexhaustible sources is "solar electric other non -electric uses of solar energy, including biomass and solar heating and cooling, are dealt with under separate headings and not in the context of development of inexhaustible energy sources. There is an unfortunate division of the solar energy option in the report which tends to emphasize the solar - electric route as the only one that can provide ultimate long-term benefits.

There is considerable discussion of the resources of gas, petroleum and uranium, but remarkably little discussion of the resource of coal and of oil shale. Coal and oil shale technology are properly ranked among the highest priority of supply, but the coal and shale resources are lacking in terms of how long will they last at the projected rates of extraction.

We find the coal gasification time table to be too long. It can be materially shortened by proper emphasis. Similarly, we believe that marine biomass should be put into an equal time frame with terrestrial biomass.

The remarks on environmental protection seem to indicate that that is more important than the supply of energy. While protection of the environment is very important, we believe that the case of the environmentalists has been over stated. Emission levels have been set at unreasonably low levels without adequate proof of the need. We agree to the need expressed in the plan for research on the establishment of these levels. We would also suggest work toward establishing the amount of the overall energy dissipation which occurs in reaching the emission levels and work to minimize this use of energy.

While energy resource assessment is included in the Plan, we feel it should be given a much higher priority than is indicated.

The summary (page 5 -8) calls for industry to "Play the major role (financially and technically) in large demonstration and near -commercial projects" and to "Commercialize the technology It is very doubtful that industry has the resources to bring the required gigantic revolution in energy supply to reality in the short time required. Much more government support will be required than is presently planned.

In order that the stated objective to "Shorten the time for transition to new fuel forms . . . " may be accomplished, a drastically speeded up contracting procedure is required.

The plan uses the scenario technique of technological forecasting. Five energy scenarios are postulated, and the report makes it quite clear that none of these scenarios is expected to represent a case which is likely to occur. They are "what if" exercises. The only scenario which is stated to provide an acceptable level of imports by the year 2000 is the one in which all possible technology options have been exercised. While we believe this conclusion is valid, "the case is not really proven.

There is only one scenario in which a specific technology is omitted or constrained, and this is the one in which nuclear development is not allowed to continue. Clearly, under these circumstances an unacceptable situation arises. There are no scenarios in which other energy technology options are withheld. It would also be important to assume partial successes at faster or slower rates.

The organization of Vol. 2 could be improved. Topics in several cases appear to be out of order and/or separated; for example, the separation of storage technology from solar technology. In discussion of solar energy, little emphasis is given to the need for storage systems, and energy storage development is treated at a different priority level to that of solar energy, and is discussed in a completely different context. Energy storage is ranked at a fairly low priority because it is included in "Technologies Supporting Intensive Electrification, "while solar-electric generation is ranked with the highest priority technologies because it is considered an inexhaustible source for the long term.

Discussion of Specific Technologies in Order of Presentation

Direct Combustion

Plan is limited to fluidized bed combustion. Is stack gas cleaning completely developed or is there some other reason it is left out? There are many other potential applications of direct combustion which deserve attention.

Demonstration Plants

It is our understanding that the pipeline gas demonstration plant projects will be selected from competitive bids in response to an RFP. It is unlikely, at present, that various gas distribution and transmission companies located in different states will be able to present combined bids although their ultimate objective is common. 'It may be necessary for ERDA to find a way to bring the various state, local and industry interests together to minimize the cost and enhance the strength and probable success of the effort.

" The time schedule on pipeline gas can be materially shortened if a proper effort is made.

Enhanced Oil and Gas Recovery

This is a vital program and deserves the emphasis it is receiving.

Pipeline Gas

This is a very important program. The means of bringing gas to the market place economically and safety is in existance. This is not true of an expanded electric supply. Industry is being badly hurt by curtailments. ' Gas can directly decrease the need to import oil.

The presentation is good and the time table seems obtainable. Plans for third generation processes and second generation process improvements in support of the demonstration program should be included.

Oil Shale

The plan only refers to in-situ recovery technology. Aboveground retorting needs research and the production of pipeline gas presents a great developmental opportunity.

Fuels From Biomass

The delay of the marine program relative to terrestrial biomass seems unfounded. We see no reason that it cannot proceed, at least as rapidly as the terrestrial. Both are of vital importance.

Solar Heating and Cooling

This is a very important opportunity for near, mid- and long -term energy supply. We feel that although some direct commercial applications are immediately possible, a great deal of R, D&D is needed. A thorough investigation is required of where solar" augmentation can be applied to industrial processes.

Geothermal

The program objectives, as classified by time periods, are reasonable.

The exploration and assessment efforts described under Strategy (1) are insufficiently comprehensive. The Government should ensure that an appropriate level of effort is applied to advanced geophysical exploration sciences and technologies. For example, we understand that the U. S. S. R. is already using an MHD magnetic pulse generator for geophysical hydrocarbon exploration, and it seems reasonable to question whether this or comparably imaginative techniques might be applicable to geothermal exploration. Even though the credibility of geothermal r es our c e adequacy of some types of resources must be more fully established (a need that we ourselves do not regard as generally pressing), a need also exists for effective and economic means to find and delineate geothermal reserves of the various types.

INS" TITUTE OF GAS TECHNOLOGY

The intended extent of activity directed toward active volcanic energy utilization, as compared with some of the other approaches, is not clear. Although it does not deserve top priority at this time, we favor the prosecution" of an aggressive, positive approach extending quickly well beyond "a" test facility, presumably one with rather narrow capabilities. Many concepts suggest themselves as worthy of serious consideration at an early date. More ambitious conceptual approaches, such as, perhaps, the use of terrenes, should not be kept on the shelf too long.

Conservation in Buildings and Consumer Products

Development and demonstration of conservation technology and of in. stitutional changes to aid the utilization of solar energy in new and existing commercial and office buildings for heating and cooling should be promoted in the near term (-1985) for the following reasons:

1. Initial results from U. S. Government funded studies (e. g. , G. S. A. , ERDA re: Dubin-Mindell-Bloome Assoc. New York) have shown both technical feasibility of significant energy reduction by retrofit or new design and cost effectiveness.

2. Adequate technology for additional energy reduction by utilization of solar energy has been demonstrated abroad (Australia) for certain commercial buildings.

3. Problems of implementation by private sector due to lack of awareness, institutional barriers, and cost of collectors, can be overcome by a continuous and vigorous government supply of such R, D&D activities enhanced by broad educational initiatives, in cooperation with other

organizations (such as AIA, ASHRAE, SPE, etc.), tax incentives or low cost Federa1 loan inducements to use solar energy alone or as hybrid technology with conventional approaches and support of research to advance mass production technology of solar collectors at reasonable cost.

-Development of cost effective methods of retrofit of existing installations of space and domestic water heating to recover combustion heat lost in the flue is begging the problem. The barrier is safety associated with the need for proper draft and potential premature deterioration of heat exchanger from attendant water condensation in the flue. A more cost effective and safe approach would be to increase by retrofit approaches the seasonal efficiency of utilization of space and water heaters by such means as to reduce the burner -off time losses of conditioned air. While such approaches are known (flue dampers, proper sizing, modulating burners), there is need to establish the magnitude of their potential for energy conservation in order to demonstrate cost effectiveness to the homeowner.

Electric Conversion Efficiency

The program is vitally needed but the approach is weakly stated and incomplete. Improving the energy conversion efficiency should occupy the highest governm ent priority sine e it is *one* of our best m cans of conservation-making existing fuel reserves (both fossil and fission) las t longer.

The **strategy** discussed seems to consider superficially the severe materials problems and limitations encountered by some advanced energy conversion systems. The Electric Conversion Alternative Study (ECAS) is mentioned. This program represents a good start in the direction of **asses sing** advanced systems. However, care should be used in interpreting the preliminary results which have just been received. Thus far, the study **has been biased toward base load plants and has not considered materials limitations. As a result of the base load bias, systems such as fuel cells** which operate best as peakers or in a dispersed fashion (in the electrical distribution system) have not been considered equitably. This bias should be recognized and proper attention should be given to fuel cells. Fuel cells **are** not Carnot cycle limited and, therefore, show the best potential for achieving the stated 55% efficiency when combined with a gasification plant.

Electric Power Transmission

The approach is sound. No mention is made of the problem of addressing transmission over longer distances than are now typical. Distribution system **improvements are included in the Objectives, but are omitted from the** Implementation Program. Cryogenic systems are limited to very high capacity lines. The role of large capacity lines and their reliability problems must be addressed in an overall systems study before **large coremitments to cryogenic system technology can be justified.**

Power transfer requirements will inevitably increase and make improve. ments in Transmission Technologiess both de sir able and imperative. Until order -of -magnitude improvements are made in the Transmission modes, however, it must be recognized that physical laws probably impose a rather tight ceiling on how much present performance can be improved before” rapidly diminishing returns are felt. Such barriers can not be realistically overcome by shifting development costs from rate -payers to tax-payers.

The Federal Role should fall largely in this scientific field with emphasis on the potentia1 conservation of all r es our c es (land, aesthetics, public health and safety, etc.) rather than primarily materials resources. As an example, " the NBS should continue or expand its research on cryogenic and superconducting materials, but the electric utilities and their suppliers should translate the findings into transmission line technologies and should be allowed adequate service rates to do so. Then if the approach is deficient, the system will be economically self-correcting as high electric rates provide an umbrella for competing energy transportation technologiess.

The Federal R&D agencies have much to offer and their potential contributions are too valuable to be unnecessarily diluted by hardware programs.

Electric Transport

The program is much needed and the general approach is good. However, some omissions occur in the objectives and in the information plan. Objectives to produce prototype automobiles with 60, 100, and 200 mile ranges can be met today, and do not need research, if this is all that is needed. These objectives must include a reasonable vehicle weight target, capital cost target, and operating cost (batter y replacement cost) target if they are to be meaningful. These additional qualifiers on goals should be clearly stated as they are vitally important to formulation of a research plan.

The "problems" do not place enough emphasis on the development of low cost charging systems, provision of electric distribution capability for recharging a large-electric vehicle population, development of inexpensive and reliable vehicle control systems and cost reductions on electric motors and drives. These aspects are also missing from the implementation plan.

The general comments on implementation makes the implicit assumption that electric vehicles will have an overall favorable impact on the national energy and economic situation. Some overall systems analysis and a corn. parison with the alternative nonelectric, nonfossil fuel vehicle should be made. This is missing both here and in the "Transportation Efficiency" program.

There is an overlap of effort in the Stirling engine program discussed in this program plan and also in the "Transportation Efficiency" plan. Some definite procedure for coordination of these two efforts is required.

Many of the technologies discussed in the electric -rail transport section are already in use in other countries. The plan quite correctly emphasizes a study of existing foreign train systems. The study should also encompass a review of research in progress by foreign laboratories aimed at electric rail traction. It is to be hoped that the reference to "third rail" electrification also implies overhead catenary electrification, which is the more usual way of supplying power to modern rail systems.

Energy Storage

The program is needed, and is well presented, but with some omissions, overlaps, and conflicts.

The near term objective of providing for 6% of delivered electricity to come from storage by 1985 must be critically retie wed in the light of potential availability of relatively low-cost off-peak power. Recent studies (IGT) have shown that within a 10-year time frame, only small amounts of off-peak nuclear or coal based power will be a available for storage: most of the peaking generating capacity is oil-burning and gas turbine equipment not suited for coupling to storage systems. The need for energy storage will develop in the future as a) the storage technology becomes available and thus changes the base-load construction priorities, and b) as more nuclear and solar plants are commissioned.

There is a serious overlap and duplication of "storage in vehicle propulsion systems" with the separate program on ''Electric Transport. '' This must be resolved and duplication in the overall plan must be eliminated.

The objectives specifically identify the development of electromagnetic storage systems for a long term, while flywheel, compressed air, underground purged hydro and thermal storage, all discussed in the strategy and implementation plans, are not specifically mentioned in the objectives. There seems to be no reason why electromagnetic receives special recognition.

There is some concern that the hydrogen storage objective includes "transmission and utilization systems as a substitute for petroleum and natural gas fuels." This work is much needed and justified, but the words here imply a far greater impact than merely an energy 6to rage concept. The plan should state whether a broad hydrogen energy program is proposed here, and how the interrelations will be made with other hydrogen projects included in other program areas (converter reactors, solar energy, transportation efficiency, for example) will be made.

There is a possible overlap and duplication of effort in the Energy Storage in Buildings plan with the separate program on Conservation in Buildings and Consumer Products. Heat pump development, for example, occurs in both places .

Industrial Energy Efficiency

This important area has been the subject studies by A. G. A. and several gas companies at IGT for the past several years. The program has been very successful but could profit from financial support by ERDA.

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Transportation Efficiency

An excellently laid out program. More comprehensive and logical than most of the others.

Highway vehicle problems do not include development of engine systems to operate on alternative" nonpetroleum fuels (methanol and hydrogen, f or example), while these are emphasized in the implementation plan.

There are many mentions of the application of hydrogen to vehicle and train systems. Most emphasis is on the storage aspect. There is an omission of work on problems of delivery of hydrogen to the refuelling stations , its storage there, and the safety aspects of refuelling operations. There is some concern that the emphasis on hydrogen in this program is not backed up by adequate emphasis elsewhere in the plan on hydrogen production, transmission, and distribution technology. Specific mention of hydrogen as an aircraft fuel is not made, while its light weight makes it specially advantageous in this application.

Studies of hydrogen transmission in pipelines must be coordinated with the hydrogen program in the "Energy Storage" plan, and there must be a parallel comparison to the alternative of electric power transmission.

The program repeatedly stresses noncryogenic onboard hydrogen storage. This implies that cryogenic storage has either been ruled out or does not need R&D. Neither assumption is justified, but whichever has been assumed should be stated.

A 50% reduction in use of petroleum for pipeline transportation is called for, presumably by switching to electric compressor stations. This, it seems to me, might add more cost and create more problems than its worth. (In many cases, it would represent a waste of energy.)

Fusion

The Tokamak-type fusion reactor development program appears to be structured in a logical sequence. Success is reasonably assured, but we assign a low factor of confidence in schedules being met. We are satisfied to see the program continue as planned without being comfortable in any assumption that it can be depended on to fill major energy needs by 2020. This is not a criticism of the program or its personnel but simply an assessment of the prospects of the technological development progress as we see it.

By contrast, we see laser fusion as an unproven technology that might make a significant contribution to closing the energy gap even before Tokamak and its relatives become consequential. We recommend that laser fusion development be very aggressively pursued in the energy program on the assumption that it is feasible even though this is unproven. Its failure to match our wishes would be no more disgraceful than a failure of other concepts on technological, economic, safety, or other grounds. The need for a deliberate approach to CTR development has been documented to our satisfaction; the need for a restrained approach to laser fusion has not.

Breeder Reactors

We support the near -term objective as stated, and include the FFTF, the CRBR, the PCTF, and possibly some other major facilities within this frame - work.

The mid-term objective is loosely constructed, as we believe its should be at this time. Unnecessary Federal commitments to LMFBR commercialization, as distinct from technological development, should be . held in abeyance while alternatives are being aggressively evaluated. Intensive efforts should be applied to the preparation and continuous updating of realistic, integrated, energy development schedules and programs to avoid waiting too long to initiate commercialization, but the possibility of superior concepts and technologiess arising (as the y have in past years under comparatively weak incentives) should not be ignored.

We support four of the five statements of the Federal Role , but take sharp exception to the first of these five statements. ERDAs assistance on safety R&D should not be conceived as "directed toward allaying the publics . concerns" but, rather, toward ensuring safety. Public relations are important, but they should be cultivated by PR people outside ERDA. If ERDA proceeds with the stated concept of its primary (or even ancilliary) Federal Role, it is headed for oblivion and the country's important nuclear energy program will be even further emasculated. Please obliterate such words and concepts!

We believe it is not yet time, and 1978 may be too soon, for a commitment to construction of a near-commercial LMFBR (NCBR) as a follow -on to the CRBR. Before endorsing such a commitment, we would want to see a comprehensive energy development budget showing its impact.

We support the limited attentions to the GCFR, LWBR, and MSBR activities as outlined.

Converter Reactors

The near -term objectives stated are appropriate national goals but we feel that the time has come for the electric utilities to collect further needed LWR development funds from rate -payers rather than tax-payers. We sympathize with their financial problems but thes e are now lessening due largely to regulator y actions and further improvement could be rapid without further subsidy. Similarly, LWR plant and equipment manufacturers are beginning to show profits on the LWR segment of their businesses, with a strong market demand on the horizon. The Federal Role should not be one of solving electric utility operational problems and thereby encouraging further deficienciess in conventional plant designs and practices. ERDA's role should be one of s s simulating industry-utility efforts and monitoring their progress while eliminating any unnecessary governmental obstacles to progress.

We do favor Federal support (including financial support) of mid-term and longer -term objectives. It is our impression that industry is capable of developing the HTGR direct cycle power plant largely with its own resources, but we encourage ERDA to assist in the back-end fuel cycle work. that needs close coordination with other reactors fuel-cycle provisions. The availability of private funding for development of gas turbine prototypes will certainly be heavily influenced by the more positive Federal attitude toward the HTGR, including its fuel cycle.

We particularly encourage early, aggressive efforts to develop the VHTR reactor and related systems suitable for application to industrial chemical processing, including conversions of organic and/or inorganic materials to essential, non -electric energy forms. Systems work will be costly, but it should include the early study and demonstration of the coupling of the VHTR cool and loop to several important industrial heat absorbing processes. It is not clear that this essential activity has been assigned a suitably high priority.

Attention should also be given to adaptation of the HTGR for the purpose of H_2 or synthetic fuel manufacture. Analysis of industrial applications of process heat other than in H_2 or Synfuel should be included. Iron and steel . and cement and stone industries in particular should be investigated.

Use of process heat is not included in the "Problems" or **"Implementation"** program. One particular additional problem is that of coupling the HTGR coolant loop with industrial heat-consuming processes, and adapting the reactor to accept the return of coolant still at a high temperature.

Use of process heat for thermochemical hydrogen production, for coupling to coal and oil processing technologies, to iron and steel production, is already under examination at ERDA and should be continued.

We have frequently been dismayed by the complete disregard for process **heat demands as a factor in the analysis of uranium adequacy.** We **regard nucles energy as an indispensable major source of o-ii and gas energy replace - ment that can be used most efficiently and effective 1 y if it does not first go through a conversion to electricity. This observation should be weighed carefully throughout** ERDAts nuclear and non-nuclear en erg y development planning.

The whole program effort is too heavily emphasizing the production of electricity, and not **the** use **of nuclear energy in other (thermal) forms.**

Hydrogen

The technology of hydrogen in energy systems receives mention in the context of storage and energy transmission. Because it is still at the study status, and has a long term of impact, and presumably because it has no net energy supply impact in the long run, it received the lowest ranking in national priority. In the Glossary section, hydrogen energy is defined as including non-electrolytic methods of hydrogen production and methods for its storage and transport. Specific mention of the electrolysis process, and of the utilization of hydrogen, is not made. In discussion of the need for increases in the capacity of energy transportation systems, rail movement of coal and pipeline movement to fluid fuels and slurries is discus seal, but no mention is made of the increasing needs to move either electricity or for hydrogen transmission option. In none of the 5 scenarios, and particularly in the combination of all technologies (scenario 5), does hydrogen transmission or any form of bulk energy storage appear (neither does fuel cell or any other form of decentralized conversion appear in the scenarios, although the use of hydrogen energy, bulk electric storage systems, and fuel cell generation are discussed in the plan as developable technology options).

SIERRA CLUB

Mills Tower, San Francisco 94104

Sierra Club Research

July 16, 1975

Jon Veigel
Congress of the U.S.
Office of Technology Assessment
Washington, D.C. 20510

Dear Mr. Veigel:

I have carefully read the two volume ERDA decision document: "A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future." The document reflects a major conceptual improvement over earlier work, such as "project Independence.'! The presentation of supply alternatives allows a clearer public understanding of exactly what the federal government plans to accomplish in the next few years. It is a straightforward presentation of technological options.

I would most strongly recommend that the application of funds for research, development and demonstration also consider social and economic issues. This ERDA report/plan focuses too strongly on supply questions and fails to follow through on the recognized realization that energy is not unlimited and that prices will be high. Future analysis should treat a broader range of social choices which can achieve improvements in the quality of life. Research, development and demonstration might also be spent on social. demonstrations such as lifestyle changes in addition to energy conservation research which treats technological improvements.

The documents suggest that federal energy policy is based on a series of goals necessary to achieve less dependence on imports, but the report fails to explain the following:

1) How much these drastic supply goals will cost America - what are the implications of domestic dependence?

2) How environmental impacts are to be treated.

3) Under what conditions a supply goal will be reduced or expanded.

4) What changes in the distribution of wealth and political power are likely under each supply scenario.

5) The anti-trust implications or the rate of timing of the plans.

6) How public access will be incorporated into the ERDA plans, particularly in choices of technological implementation.

7) What the corporate contribution to this research will be - who will capture the profit from the output.

I am particularly concerned over the presentation of the time tables contained in Volume 2. The process for making these plans and the conditions which would lead to a sequence modification are not specified. I would think that the public interest would be well served by a description of explicit conditions which would lead to the abandonment of a technology and the flexibility of choice which is contained in the plan. For example, if nuclear plants were to prove unacceptable ten years from now, how would America phase out the existing stock? One wonders what the economic distinction is of dependence on foreign oil over which we have little control and dependence on a questionable technology which becomes so dominant that a phase out is impractical. Energy independence should be analyzed in the context of social protection from unexpected events of all sorts. One even might wonder whether the oil import uncertainty is as major a policy concern as the technological failure potential. As a start, an analyses might show the national consequences of a loss of expected energy supply for each source of the technologies in this ERDA document for each yearinthe planning process. Thus, the energy policy which chooses the source and timing of energy exploitation would implicitly consider the uncertainty of availability. In this sense, the cost of a reduction in the use of energy would be analogous to an insurance premium paid to avoid the potential high cost of a drastic, rapid curtailment of energy use.

Underlying all my comnents is a concern that the proposals for R,D,&D will not be responsive to economic, social and environmental factors. If re-seach is pursuedto obtain a supply goal and the goal is achieved, we are not automatically assured that resources will be used efficiently or that federal funds have not been wasted.

Again, I would like to congratulate the authors on a much improved decision document. The problem is to now convince the government that the supply strategy is not an ultimate solution to the energy problem and to expand the scope of future federal research to include social options.

I am interested in cooperating directly, and in greater detail, in the early stages of future ERDA decision plans. Please consider the advantages of professional resource economics input from research organizations such as Sierra Club Research.

Sincerely,

Steve Andersen

Stephen O. Andersen
Resources Economist

SOA/cLG

cc: Sid lbglewer

AMERICAN PUBLIC POWER ASSOCIATION

2600 VIRGINIA AVENUE NW WASHINGTON DC 20037 • 202/333-9200

Action JV
Info EQD
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Rec'd 7/25
Preparation of reply for sig of
Action #
Suspense

July 24, 1975

Emilio Q. Daddario
Director
Office of Technology Assessment
Congress of the United States
Washington, D.C. 20510

Dear Mr. Daddario:

I appreciate the opportunity for the American Public Power Association to comment on the Energy Research and Development Administration's National Plan For Energy Research Development and Demonstration. We hope that the Office of Technological Assessment and Congress will find our comments useful in analyzing ERDA's study.

APPA represents more than 1,400 local public power systems in 48 States, Puerto Rico, the Virgin Islands and Guam. More than 30 million people receive their power from local public power systems in towns ranging in size from Reynolds, Nebraska with 60 meters to the City of Los Angeles with over 1,000,000 meters. Local public power systems have a generating capacity of about 40,000 megawatts.

Local public power systems seek to provide adequate and reliable electric service at reasonable price and in an environmentally acceptable manner. Since national energy research and development will certainly be a factor in the ability of these systems to obtain their goal, APPA has commented to ERDA on both the national energy research and development plan and the Solar Energy Research Institute. Copies of both comments are enclosed and referenced.

GENERAL COMMENTS

In my April 29 letter to Dr. LeGassie, I listed criteria on which to base energy systems priorities. Many of these criteria appear in Chapter X of Volume I of A National Plan For Energy Research, Development & Demonstration as unresolved issues.

Net Energy: ERDA should have considered net energy in formulating a national energy plan for R&D. Net energy is a yardstick with which to measure the energy output for a given energy input, and it provides one measure of the relative attractiveness of competing energy systems.

cost: While ERDA claims to have considered costs in forming their national plan, there are no cost figures in either Volumes I or II of the National Plan. It seems to me that you must know "what you are getting for how much" before you can allocate resources wisely.

End Use: A high priority should be placed on a sustained effort to develop the technology to convert consumer products and industrial processes from gas and oil to methanol and electricity.

Regional Analysis: In our comments to ERDA, APPA recommended a regional approach to the development of a national plan. This approach would highlight the regional nature of most energy technologies, identify resource rich areas, and point out the unique environmental problems associated with each region. With this additional information, one could optimize the energy-mix for each region and determine whether a given region is likely to be energy rich or poor, in terms of meeting its energy needs. This information would indicate the amount and type of energy to be transferred from one region of the country to another.

Water: APPA believes that the ERDA comments on water resources in Chapter IX of Volume I of the National Plan would not have been made if a regional analysis had been made. ERDA's comments average out regional water shortages by speaking of the problem on a national basis. Along these same lines, there is a critical need to develop non-water consumptive technologies for electrical generation.

Another area of concern is what we view as the lack of sufficient input by the user of the energy system to be developed. It is essential that users, regulators and other local governmental officials understand and plan for the energy systems being developed. The user should be involved in the planning, design and specifications of these energy systems. Advisory committees composed of these groups should be formed for each major technology to insure that user needs are met. The Federal government should retain control of all Federally-funded research, development and demonstration projects with advisory committees to appraise and advise on each program from beginning to end.

INDIVIDUAL TECHNOLOGIES

Solar: While APPA believes that ERDA has outlined a reasonable solar energy policy, we are disturbed by the comment in the draft document that the Solar Energy Research Institute mandated by Congress will be run by a contractor (see our enclosed letter to Dr. Teem).

Fuel Cells: This is a technology barely mentioned in the ERDA National Plan, and yet it represents a technology in which private industry has spent over $100 million over the past 8 years. The technology is non-polluting at point of use and may be operated on fuels such as methane, methanol, natural gas, and hydrogen and oxygen. It can be used for direct electrical generation on its own or for energy storage with solar technologies. Its demonstration would be rather inexpensive and near-term when compared with other energy systems.

Fusion: ERDA offers no alternative to its development of the Tokamak. ERDA's fusion effort should be a balanced effort with energy programs in both electron beam and laser fusion.

Emilio Q. Daddario
July 24, 1975
Page Three

Although there is much we like in ERDA's National Plan, we believe that the formulation of such a plan should incorporate the items discussed in our "General Comments". As far as the individual technologies are concerned, the problems that we raise with solar, fuel cells and fusion can be readily corrected. These comments are not an attempt to judge ERDA's overall effort, but to point out considerations that would improve their initial effort.

Sincerely,

Alex Radin

AR/dt
Encl.

AMERICAN PUBLIC POWER ASSOCIATION

2600 VIRGINIA AVENUE NW WASHINGTON DC 20037 • 202/333-9200

April 29, 1975

Mr. Roger W. A. LeGassie
Assistant Administrator for
Planning and Analysis
United States Energy Research
& Development Administration
Washington, D. C. 20545

Dear Mr. LeGassie:

I appreciate the opportunity which you have afforded the American Public Power Association to contribute to ERDA's formulation of a national energy research and development plan.

APPA represents 1,400 local public power systems in 48 states, Puerto Rico, the Virgin Islands and Guam. More than 30 million people receive their power from local public power systems in towns ranging in size from Reynolds, Nebraska with 60 meters to the City of Los Angeles with over 1,100,000 meters. Approximately 80% of APPA member systems do not generate electricity but purchase power from other utilities. APPA member utilities provide 10% of the nation's electricity with a generating capacity of 39,508 megawatts.

Local Public Power systems seek to provide adequate and reliable electric service at reasonable price and in an environmentally acceptable manner. National energy research and development will certainly be a factor in the ability of these systems to obtain their goal.

We believe that the decision-making process (criteria) on energy R&D should first assess the impact of various energy technologies on the efficient use of resources, the environment, the public health and safety, the national interest, and the utility industry. Based on these studies, judgments should be made as to the acceptability of each of the energy technologies. For those technologies judged unacceptable, projections should be made as to how the energy technology could be made acceptable. Estimates should also be made as to when new energy technologies will be available for commercial operation for various levels of R&D effort. Then, for a given date, those energy technologies which are available and acceptable would be optimized in terms of:

1. the ability of the technology to meet projected electrical demand;
2. health and safety considerations;
3. environmental considerations;
4. resource availability and net energy consumption; and
5. the cost of developing, producing, and using the technology.

These studies should be done on a regional basis to provide an opportunity to introduce as much diversity as possible into the energy mix. The optimization variables should be regional in character where possible. A final national model should be developed from a composite of the regional studies. Using this composite model as a starting point, comparisons should be made between (a) the *use* of relatively inexpensive generation in one region with transmission to another region and (b) the use of more expensive generation within a region as given in the regional model.

Environment. The factors considered in making this determination should include cost, environmental impact, transportation, resource displacement (the transport of water in a slurry pipeline from a water deficient region to a water rich area), and overall energy efficiency. Since both providing electricity and preserving the environment are in our opinion desirable goals, decisions should be made as to what constitutes a tolerable level of environmental impact. While sources of electrical generation which minimize environmental impact should be developed, for the next generation they will not provide adequate electrical energy. Therefore, trade-offs between energy and the environment must be made. Trade-offs must be based on the best available technical information, and made on the basis of balancing of costs and benefits and consideration of the attitudes of the people affected by the decision.

National Interest. If the "oil crisis" taught us anything, it showed us the importance of developing a balanced energy policy which minimizes our dependence on foreign resources or on a single fuel. It also pointed out the need for more efficient production and use of energy as well as the need to assess all energy and environmental control technologies on the basis of net energy.

Health and Safety. The projected health impact for present and future generations of the technologies being developed **and their fuel cycles** should **be assessed. This assessment, coupled with the prevailing public attitudes towards what constitutes acceptable risk, should** provide the basis for decisionmaking on health. Energy systems should be designed for maximum reasonable safety during construction, operation, and maintenance. The energy fuel cycles should also be designed for maximum reasonable safety.

User Criteria. The development of energy technology should always be clearly focused on the end-use of the technology. New energy systems should be designed with an eye toward compatibility with existing utility systems. The program to develop the new technology should aim at keeping capital and operating costs of commercial equipment low while insuring that vendors can provide sufficient quantities of new equipment replacement parts and fuel to obtain the quickest possible application of the technology. The energy system should be efficient, reliable, durable, and easy to repair. Designs should be standardized and construction modular where possible.

ERDA

For ERDA to effectively deal with the intricate problems for which it was created, it must define its goals so that if those goals are met the problems which led to its formation would be solved. A clearly defined approach to meeting these goals should be developed and followed, along with the philosophical underpinning for this policy. The policy would represent the administratively most efficient means of applying the "principle of least action", which is reaching the desired goal in the shortest period of time, with the greatest possible economies of effort and resources. To keep ERDA vital, periodic review of its goals, policies, and philosophy should be made to examine the agency's successes and failures plus changes in the overall energy situation. Every five years or so, the agency should reassess its studies on the optimum mix of energy systems. This reassessment should reflect technological advances and developmental failures, shifts in public attitudes toward the various technologies or the criteria used in decision-making, and new information on the impact of various technologies on the criteria used in decision-making. On the basis of this information, five year program plans should be developed.

To assure user acceptability and equipment availability, ERDA should work closely with all segments of the utility industry and probable vendors as well as with ERDA contractors. But it is imperative that close cooperation with these groups not lead to monopolies on either the technologies developed or the fuels used.

Allocations of Resources

Two ways of looking at the projects to which ERDA will be devoting its efforts are: (a) the nature of the work performed and (b) the time-frame in which technologies will be brought to commercial operation. The kinds of activities that ERDA labs and ERDA contractors will be involved in appear to be basic research mission-oriented R&D, and proof-of-concept experiments. A reasonable allocation of resources might be 15% for basic research, 45% for mission-oriented R&D, and 40% for proof-of-concept demonstrations. Another way of looking at this is to provide 15% of the available funding for projects likely to be brought to commercial operation in 25 years or more, 45% for projects commercially available in less than 10 years. There will obviously be a great deal of Overlap between long term projects and basic research as there will between near term projects and proof-of-concept demonstrations, but by simultaneously meeting both sets of requirements, balance will be assured. It should be noted that long term basic research will provide a needed pool of manpower to draw upon during the development phase.

PROJECTS OF APPA MEMBER INTEREST

Presented below are some projects of special interest to APPA members and and indication of APPA's concern about these projects.

Fossil Fuels

Gasification. Coal gasification offers an opportunity to use a relatively clean fuel, when compared to coal, for generating electricity. The price for this clean-up is higher cost for the fuel, solid waste products from the cleaning process, and increased water consumption. The loss of efficiency due to the gasification process means increasing either strip or deep mining to povide the same amount of energy. Gasification should be compared with other ways of obtaining the same results in order to determine the extent of its future use. Many of these same arguments apply to oil shale liquefaction.

MHD. MHD appears to be an effective method of increasing the energy efficiency of coal burning steam electric generating plants. The Soviets are reportedly testing a 75 MW power plant with an MHD generator using natural gas. Studies indicate that the nitrogen oxides can be controlled by using a fuel-rich mixture. . Sulfur oxides would react with the alkali seed material to form compounds recovered by the electrostatic precipitators. For economic reasons the alkali metals must be recovered and a by-product of that is control of sulfur. With a steam turbine as the second stage of power production, the discharge of waste heat into the cooling water would be well below that of any existing steam power plant. If a gas turbine is used for the second stage, the need for cooling water is removed. Unfortunately, to reach the required temperatures for MHD, auxiliary heating or an oxygen enriched atmosphere is required.

Nuclear Power

Breeder Reactor. The breeder reactor may become an important element in our methods of electrical generation over the next half-century. A balanced approach to the breeder, as one of three or four major forms of electrical generation, would be to fund the high-temperature gas-cooled reactor and the light-water breeder as well as the LMFBR. In addition, some of the reliability and safety questions raised about the LWR are magnified in the breeder case. The nuclear waste-disposal problem must also continue to be studied.

Renewable Resources

The whole range of solar technologies hold the promise of meeting a significant portion of the nation's energy needs over the next forty years. In certain regions of the country, it may become a major method for generating electricity. The Pacific Northwest, is heavily dependent upon hydro power, which currently provides about 14% of the nation's electricity. While the development of new hydro sites cannot keep pace with projected electrical demand, many previously marginal sites could be developed, existing sites could be redeveloped for increased capacity, and bulb-type turbines should be developed for use both in hydro projects and possible tidal installations. On a net energy basis no method of electrical generation is as favorable as hydro.

The development of first generation solar heating and cooling seems well along, and an evaluation of the integration of this technology into the utility industry is deserving of study. The economic use photovoltaic cells, solar thermo-electric, ocean thermal, and wind turbines is regional in nature.

Development and use of solar technologies over the next 25 years could allow them **to take their place along side hydro as a major factor in electrical genera-**tion **during the first quarter of the next century.**

Except for ocean thermal, an efficient and widely applicable energy storage system is required to make solar systems viable. While pumped-storage and batteries will probably be commonly used, a fuel cell using a fuel such as hydrogen may prove to be the best form of energy storage.

Geothermal energy is an efficient method of generating electricity'.' Its application will be limited unless new ways of tapping geothermal fields are perfected and the environmental problems associated with using geothermal energy are solved.

Fusion

APPA supports the development of both laser fusion and magnetic containment. The laser approach appears to be the only one that offers many of our members the possibility of actually operating such generation. Large fusion generation plants would probably be jointly owned by all segments of the industry. Concepts such as the KMS approach to produce methane with laser fusion should be studied to determine whether or not it has advantages over direct electrical generation with fusion. A pressing need in this area seems to be the development of an efficient high energy laser.

Fuel Cells

In addition to being an effective way to store energy for solar systems, fuel cells promise inexpensive and reliable energy. They should be easy to install and are modular so that fuel cells can be sized to meet the needs of almost all utilities. There appears to be little environmental effect associated with generating electricity with fuel cells. A unique approach to using fuel cells is being studied by the City of Seattle. The fuel used in the cell would be obtained from converting the methane, from pyrolysis of solid waste, to methanol which is used in the cell.

April 29, 1975

Congress mandated that ERDA decide their energy priorities on the basis of:

1. power related values of energy sources;
2. preservation of material resources;
3. reduction of pollutants; and
4. export market potential (including reducing imports).

I believe the projects and evaluation scheme I have outlined meets those requirements in a rational way.

Sincerely,

Alex Radin

AE:mls

June 17, 1975

Dr. John M. Team
Deputy Assistant Administrator
for Solar, Geothermal and
Advanced Energy Systems
Energy Research and Development Administration
1707 H Street, N. W.
Washington, D. C.

Dear Dr. Teem:

These comments on the role of the Solar Energy Research Institute mandated by the Solar Energy Research, Development and Demonstration Act of 1974 are a response to an ERDA request for views published in the June 3, 1975 Federal Register.

The American Public Power Association is a national service organization representing more than 1,400 local publicly owned electric utilities in 48 states, Guam, the Virgin Islands, American Samoa and Puerto Rico. Because our membership is interested in providing adequate amounts of reasonable priced, reliable electricity in an environmentally acceptable manner, APPA has a substantial interest in the development of economical solar energy systems to generate electricity or to supplement electric@. With a membership as geographically diverse as ours, APPA is interested in most forms of solar energy utilization.

we believe the role of the Institute should be to facilitate the utilization of solar energy, and that the Institute should be organizationally separated from other ERDA solar activities. The Institute should focus on R&D on those system components which are unique to solar energy. Related work in fields such as material science should be contracted to other agencies or research organizations. The Institute should have test facilities at appropriate sites for testing all fores of solar energy, and should be the national lab for solar energy.

System analysis activities of the Institute should include the development of Conceptual designs for solar systems which are tible with off the shelf non-solar components. The Institute should evaluate overall system performance and establish system, component and material standards for solar systems. 1t should also develop designs which are responsive to the concerns of an economic group within the Institute.

An economic group should be concerned with all aspects of marketing solar equipment, developing a strong solar energy industry, and resting solar components and systems.

A communications division in the Institute should compile data in and provide information from a solar energy bank, as we11 as function as a public information office.

I hope that you find these comments useful.

Sincerely,

Alex Radin

~jbk

ERDA AND THE CONGRESSIONAL ACTS

This section weighs issues regarding ERDA's Plan and Program against provisions in two Congressional Acts, The purpose is to compare ERDA's direction with Congressional intent.

The specific issues used in the comparison are the 16 major issues identified by OTA's Overview Task Group. These are explained in detail in Chapter I.

The laws applied as yardsticks are (1) the Federal Nonnuclear Energy Research and Development Act of 1974 (PL 93-577), and (2) the Energy Reorganization Act of 1974 (PL 93-438). The first law established the comprehensive Federal program for energy R, D&D, and the second law established ERDA and designated it as the lead agency in the program.

1. The Nature of the National Energy Policy Goals

Issue: The national energy policy goals as stated by ERDA deserve review and clarification.

The R, D&D Act: Sec. 3(b)(l): "The Congress declares the purpose of this Act to be to establish and vigorously conduct a comprehensive national program of basic and applied research and development including but not limited to demonstrations of practical applications of all potentially beneficial energy sources and utilization technologies within the Energy Research and Development Administration."

Critique: ERDA's Plan states five national energy goals to which energy R, D&D should contribute. Summarized briefly, they are national security and policy independence , . . a healthy economy. , . preservation of life style options , , , aid to world stability. . . and protection of the environment.

These goals and the emphasis among them warrant careful Congressional review.

Such review would seem important first because the goals provide the policy framework for ERDA's Plan and Program. Unless there is agreement between the Administration and Congress on these fundamental policy guides, serious disagreement and delay could well occur with respect to ERDA's establishment and implementation of the R, D&D effort.

And Congressional review would seem to take on additional importance when the great potential impact of priorities among the goals is considered. For instance, ERDA's emphasis on the goal of self-sufficiency as opposed to the goal of environmental concerns will have major consequences for future quality of life and economic well-being. Similarly, the emphasis on self-sufficiency rather than international cooperation will have major impacts on our foreign policy.

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 1976) was largely an outgrowth of decisions made prior to the Arab oil embargo, and should be re-examined.

The R, D&D Act: Sec. 2(c): "The Congress hereby finds that the urgency of the Nation's energy challenge will require commitments similar to those undertaken in the Manhattan and Apollo projects; it will require that the Nation undertake a research, development, and demonstration program in nonnuclear energy technologies with a total Federal investment which may reach or exceed $20 billion over the next decade."

Critique: The scale of the present Federal energy R, D&D program appears heavily influenced by two factors.

First, in December 1973, there appeared the Dixy Lee Ray Report to the President on energy R, D&D. This report, largely prepared before the oil embargo, was geared to an $11 billion 5-year program of energy R, D&D.

The second factor is the $20 billion, 10-year guideline supplied by Congress in Section

2(c) of the energy R, D&D Act, as quoted above.

The proposed Federal energy R, D&D budget is now within the guidelines set forth by the Dixy Lee Ray Report. However, in view of the country's post-embargo emphasis on energy independence, it is by no means clear that this budgetary framework is adequate.

As possible alternatives, ERDA should prepare R, D&D programs for higher overall budget levels, e.g., $20 billion and $30 billion for the 5 *years beginning* FY *1976*. (It should be noted that the Congressional guideline cited above provides that the budget might reach or exceed the ten-year $20 billion level,)

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

Issue: The ERDA program does not place sufficient emphasis on international considerations,

The R, D&D Act: Sec. 6(b)(2) establishes a basic objective for the R, D&D program. "This program shall be designed to achieve solutions to the energy supply and associated environmental problems in the immediate and short-term (to the early 1980's), middle-term (the early 1980's to 2000), and long-term (beyond 2000) time intervals, 1n formulating the nonnuclear aspects of this program, the Administrator shall evaluate the economic, environmental, and technological merits of each aspect of the program."

Critique: If ERDA's program is ***to achieve*** solutions to energy problems, its concern should reach beyond our national borders. In today's interdependent world, the goals of energy independence, economic well-being, and environmental quality are unlikely to be fulfilled without considering international factors.

In its overall plan, ERDA identifies such international considerations. But in its implementing program, it barely recognizes them.

Under a program truly designed to solve energy problems, ERDA might well launch vigorous research efforts with respect to the global environmental effects of energy generating technologies; the management of energy supply technologies significantly affecting the seas; the joint creation of targets of energy conservation among the major energy consumer nations,

4. Coordination of Programs Between ERDA and Other Federal Agencies

The Issue: ERDA's plans for coordination with other Federal energy agencies need to be more fully developed,

The Energy Reorganization Act: Under this Act, ERDA was established as a key instrument to meet national energy objectives: Sec. 2(b): "The Congress finds that, to best achieve these objectives, improve government operations, and assure the coordinated and effective development of all energy sources, it is necessary to establish an Energy Research and Development Administration to bring together and direct Federal activities relating to research and development on the various sources of energy, to increase the efficiency and reliability y in the use of energy, and to carry out the performance of other functions, including but not limited to the Atomic Energy Commission's military and production activities and its general basic research activities. In establishing and Energy Research and Development Administration to achieve these objectives, the Congress intends that all possible sources of energy be developed consistent with warranted priorities. "

Critique: As the above **provision indicates, Congress has given** ERDA a strong mandate as the lead energy R, D&D agency with responsibility to integrate and coordinate national efforts,

However, the ERDA Plan indicates a timidity in accepting this leadership. It is not evident in the Plan whether a comprehensive framework is being established to permit ERDA to perform the role.

The consequences could be costly,

For instance, three separate Federal agencies are now exploring technologies for coal cleanup. Without a formal structure to bring together these diverse efforts, much waste could ensure without any assurance that a technology will be successfully developed,

And without coordination, agencies concerned with different elements of a given energy technology might work at cross purposes, Regulatory requirements might clash with economic policies; technological priorities might conflict with environmental standards.

5. Cooperation Between ERDA and State and Local Governments

Issue: Success of the ERDA Program will depend in large measure on close and continuous coordination with State and local governments. The ERDA Plan does not indicate procedures or mechanisms for accomplishing this coordination.

The R, D&D Act: In Sec. 8(D)(l)(A), ERDA is instructed to establish procedures to insure that Federal energy R&D assistance addresses the full range of energy problems—from extraction to end-use—in various regions under "real life" conditions. "The Administration shall, within 6 months of enactment of this Act, promulgate regulations establishing procedures for submission of proposals to the Energy Research and Development Administration for the purposes of this Act. Such regulations shall establish a procedure for selection of proposals which (A) provides that projects will be carried out under such conditions and varying circumstances as will assist in solving energy extraction, various *areas and regions,* under representative geological, geographic, and environmental conditions . . ."

Critique: If the Federal R&D program is to be realistically conceived and effectively implemented, an objective emphasized by Congress in the above provision, full State and local participation would seem essential.

For instance, the success of energy programs will depend heavily on appropriate water allocation, reasonable land use regulation, realistic taxing policies, consistent environmental controls, and ultimately, on public acceptance. In all of these areas, State and local levels possess strong capabilities and valuable experience.

In its language, the ERDA Plan gives recognit ion to the need for a strong State and local role. But in its specifics, the Plan does not provide procedures or mechanisms for accomplishing this participation.

6. Near-Term Energy Problems

Issue: ERDA's Program gives very little attention to near-term (next ten years) energy problems.

The R, D&D Act: Sec. 6(b)(2): "This program shall be designed to achieve solutions to the energy supply and associated problems in the immediate and short-term (to the early 1980's), middle-term (the early 1980's to 2000), and long-term (beyond 2000) time intervals. In formulating the nonnuclear aspects of this program, the Administrator shall evaluate the economic, environmental, and technological merits of each aspect of the program. "

Critique: Rhetorically, ERDA's Plan recognizes the need to address the Nation's immediate, practical energy problems, as well as the basic, longer term questions. In fact, the plan's first strategic element is to "insure adequate energy to meet near-term needs until new energy sources can be brought on line. "

And specific aims are cited in ERDA's near-term program: Enhanced gas and oil recovery, direct use of coal, more nuclear reactors, shifting demand away from petroleum, and increased conservation practices.

But these intentions are not reflected in the "bottom line"-in the actual ERDA budget. Of the agency's total FY 1976 budget of about $1.8 billion, the only items relevant to the next decade are $80 million in funds for energy supply efforts and less than $7 million for end-use energy conservation.

7. Socio-Economic Research

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

The R, D&D Act: Sec. 5(a)(2): "The environmental and social consequences of a proposed program should be considered in evaluating its potential. "

Critique: ERDA's program plans, budgetary commitments, and professional staffing do not seem to give adequate priority to social, economic, environmental, and behavioral research needs, even though the Congressional mandate makes clear that ERDA is given responsibility beyond "technological" R, D&D.

"Nonhardware" research is needed for two reasons: (1) to better understand the relationships of energy and the quality of life, and (z) to identify nontechnological constraints to increased energy supply or reduced energy demand.

For instance, the Nation's energy R, D&D effort is confronted with this major issue: The social concern and community resistance which have become associated with virtually every energy supply technology.

Unless this "nonhardware" question—the attitude of the public—is examined and carefully weighed in evaluating energy options, massive investments in new energy supply or conservation technologies may never bear fruit.

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

Issue: ERDA's Program overemphasizes supply technologies relative to energy consumption.

The R, D&D Act: Sec. 5(a)(l): "Energy conservation shall be a primary consideration in the design and implementation of the Federal nonnuclear energy program, For the purposes of this Act, energy conservation means both improvement in efficiency of energy production and use, and reduction in energy waste."

Critique: Most of the programs inherited' by ERDA emphasize large-scale projects to increase energy supply, especially through nuclear and coal technologies,

Yet as is clear in the above provision, Congress directs that a strong emphasis also be given to R, D&D on the consumption side of the energy equation.

Such a priority has not yet been fully developed by ERDA. In fact, only about two percent of the revised FY 1976 budget sent to Congress can properly be termed applicable to "conservation" activity.

Additionally, ERDA's conservation program focuses primarily on the near-term, underestimating long range potential.

In weighing the long-term advantages between "supply" and "consumption" technologies, ERDA should give fuller consideration to cost-effectiveness, time to pay off, environmental benefits and costs, and demand on resources.

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.

The R, D&D Act: Sec. 3(b)(l): "The Congress declares the purpose of this Act to be to establish and vigorously conduct a comprehensive national program of basic and applied research and development."

Critique: Applied R, D&D aside, ERDA's program for basic research has largely been inherited from the agencies which it incorporated.

For instance, in the FY 1976 budget, virtually all the basic research funds are devoted to nuclear power and high energy science.

While these activities are important, the basic research program should be organized to better reflect the needs and objectives identified in ERDA's R, D&D Plan,

For instance, there is a need to strengthen basic research efforts in nonnuclear aspects of materials, combustion, fuel chemistry, environmental processes, social sciences, and other disciplines pertinent to the non-nuclear ERDA programs,

10. Commercialization

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

(a) **The R, D&D Act: Subsections 5(b)(l) and** (2):

> "(l) Research and development on nonnuclear energy sources shall be pursued in such a way as to facilitate the commercial availability of adequate supplies of energy to all regions of the United States.
>
> "(z) In determining the appropriateness of Federal involvement in any particular research and development undertaking, the Administrator shall give consideration to the extent to which the proposed undertaking satisfies criteria including, but not limited to the following:
>
> "(A) The urgency of public need for the potential results of the research, development, or demonstration effort is high, and it is unlikely that similar results would be achieved in a timely manner in the absence of Federal assistance.
>
> "(B) The potential opportunities for non-Federal interests to recapture the investment in the undertaking through the normal commercial utilization of proprietary knowledge appear inadequate to encourage timely results,
>
> "(C) The extent of the problems treated and the objectives sought by the undertaking are national or widespread in their significance.

"(D) There are limited opportunities to induce non-Federal support of the undertaking through regulatory actions, end-use controls, tax and price incentives, public education or other alternatives to direct Federal financial assistance.

"(E) The degree of risk of loss of investment inherent in the research is high, and the availability of risk capital to the non-Federal entities which might otherwise engage in the field of the research is inadequate for the timely development of the technology.

"(F) The magnitude of the investment appears to exceed the financial capabilities of potential non-Federal participants in the research to support effective efforts. "

Critique: The need for ERDA attention to "non-technical" concerns is well illustrated by the question of marketability.

For research supervised by the Department of Defense or NASA, there is little question of "a customer" for a new product or process. The agencies' own needs usually will guarantee acceptance of the R&D results.

But the "market" for ERDA R, D&D output will be both diffuse and, in some cases, poorly defined, The potential outlet for the results of successful programs may range from large energy companies to the local homeowner.

Thus, it would appear that ERDA will need to undertake special efforts to insure that it does not develop products or processes that simply "won't sell."

Such protection could be provided in part by including comprehensive industrial and consumer participation in the planning phase of new projects. These groups probably would have the best perception of society's requirements and the marketability of R&D output,

ERDA's Plan does not recognize or recommend the utilization of this type of input into its decisionmaking, although the R, D&D Act appears to provide ample latitude for it to do so; as follows:

(b) **The R, D&D Act: Sec. 7(a): "In carrying out the objectives of this Act, the Administrator may utilize various** *forms of* **Federal assistance and participation** which may include but are not limited to—

"(1) joint Federal-industry experimental, demonstration, or commercial corporations consistent with the provisions of subsection (b) of this section;

"(z) contractual arrangements with non-Federal participants including corporations, consortia, universities, governmental entities and nonprofit institutions;

"(3) contracts for the construction and operation of Federally owned facilities;

"(4) Federal purchases or guaranteed ***price of*** the products of demonstration plants or activities consistent with the provisions of subsection (c) of the section;

"(5) Federal loans to non-Federal entities conducting demonstrations of new technologies; and

"(6) incentives, including financial awards to individual inventors, such incentives to be designed to encourage the participation of a large number of such inventors, "

Critique: Another major problem involved in bringing ERDA programs to the commercial stage is that of "blurred competitive horizons. "

For example, although it is 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 the potential market. Thus, the construction of shale-oil extraction and refinement facilities will depend on some form of Federal subsidy.

Projects of this type may, therefore, never reach "commercialization" in the purest sense. It may in fact be desirable for the government to form special public agencies, such as Amtrak, to manage enterprises of this type. The formation of such enterprises could have significant impacts on the Nation's basic economic structure.

The present ERDA Plan does not appear to address this important problem, Yet the R, D&D Act clearly provides the authority for wide-ranging study and use of Federal incentives and participant ion.

11. Resource Constraints

Issue: It is essential that careful attention be given to assessing energy resources, since they represent assumptions basic to the ERDA program plan.

The R, D&D Act: Sec. 4(a): "The Administrator shall review the current status of nonnuclear energy resources and current nonnuclear energy research and development activities, including research and development being conducted by Federal and non-Federal entities; . . ."

Critique: Incorrect assessments of the Nation's energy resource base could result in huge waste in the ERDA effort.

For instance, overestimates could lead to the development of a new energy infrastructure that would quickly run out of fuel.

Yet there is still a great deal of uncertainty regarding the nature and extent of our energy resources. Estimates vary widely for natural gas, oil, coal, and uranium.

Clearly, ERDA should give high priority to improvements in the methods used to estimate energy resource potential.

12. Physical and Societal Constraints

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

The R, D&D Act: Sec. 6(a) requires the preparation and annual updating of the ERDA R, D&D Plan. It also contains the stipulation that the Plan be solution-oriented:

> "Such plan shall be designed to achieve—
>
> "(1) solutions to immediate and short-term (to the early 1980's) energy supply system and associated environmental problems:
>
> "(z) solutions to middle-term (the early 1980's to 2000) energy supply system and associated environmental problems; and
>
> "(3) solutions to long-term (beyond 2000) energy supply system and associated environmental problems. "

Critique: The above provision would appear to be critically important. It mandates an R, D&D effort directed not towards a means, such as new hardware, but towards an end–workable answers to energy system problems.

The distinction is essential to make. Because of the pervasive nature of the energy problem, the solutions will only partly involve technology. They will require as well the identification and analysis of a myriad of nontechnological factors.

For instance, there are key institutional and social considerations: Manpower, capital needs, information access and dissemination, regional and community impacts of mining.

And there are crucial physical factors: water requirements, materials limitations, air pollution, land use, and net energy.

With Section 6(a), ERDA appears to have strong authority to comprehensively address these potential constraints, "

In its overall response, however, ERDA has taken a much narrower view, It concentrates on developing the technologies, This approach is apparent across the full spectrum of the ERDA R, D&D package—from conservation to nuclear power.

This narrow interpretation of the law gives rise to a fundamental concern: ERDA's R, D&D may produce a wide range of new technologies, without providing the wherewithal to implement them in the "real world."

And it poses a key policy choice: If the congressionally directed solutions-oriented effort is to be carried out, ERDA should broaden its approach . . . or the job of addressing the "non-hardware" issues should be assigned elsewhere,

13. Overemphasis on Electrification

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

The R, D&D Act: Sec. 6(b)(3): "The Administrator shall assign program elements and activities in specific nonnuclear energy technologies to the short-term, middle-term, and long-term time intervals, and shall present full and complete justification for these assignments and the degree of emphasis for each. "

Critique: Breeder reactors, solar-electric systems, and fusion reactors all have basic characteristics in common: All are capital-intensive, have a low fuel cost, and are producers of electricity.

ERDA's emphasis on these as the three major

"inexhaustible" energy sources for the long-term poses serious concerns.

For instance, there may not be sufficient private capital to support almost total reliance on capital-intensive energy technologies. As a consequence, massive Federal subsidies might be required.

And while electricity has advantages, there are major uncertainties with respect to its complex generating systems. The concerns include environmental impact and the danger of equipment malfunction or sabotage.

ERDA's heavy emphasis on electrification R, D&D should be thoroughly reviewed now, before long-range alternatives are lost by default.

Other possible approaches include production of synthetic fuels by solar or nuclear energy, increased emphasis on hydrogen and biomass fuels, and expanded direct use of solar, geothermal and other direct heat sources.

While these approaches do not appear to have the ultimate potential of the major "inexhaustible," they could be vital ingredients in the future energy mix.

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

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

The R, D&D Act: Sec. 3(a): "It is the policy of the Congress to develop on an urgent basis the technological capabilities to support the broadest range of energy policy options through conservation and use of domestic resources by socially and environmentally acceptable means. "

Critique: ERDA relies on a number of questionable assumptions which tend to distort its R, D&D priorities, overemphasizing some options and neglecting others.

These assumptions include the following:

- ERDA's projections of future U.S. energy options assume the same set of final demands. The possibility of major reduction in energy growth because of higher costs is not taken into account;

- In calculations of the capital needs for new energy supply systems, consumer costs are not included, This could result in overoptimistic projections of the society's ability to pay for expensive new energy technology;

- **ERDA assumes that the strategy of improved efficiency in the "end use" of energy—in the home, in transportation, etc.—will have significant value only for a limited period, after which the agency expects exponential energy growth to resume.**

Based on these assumptions, ERDA justifies its heavy tilt towards the high technology, capital-intensive energy options which hopefully would produce massive new energy supplies.

In fact, simpler, less-expensive technologies may prove to be essential, major components in the Nation's energy future, This would be especially so if energy growth permanently slows and the availability of capital and key natural resources is permanently constrained.

15. ERDA Management Policy

Issue: ERDA's present management policies could hinder achievement of its goal,

The R, D&D Act: Sec. 4(b): "The Administrator shall formulate and carry out a comprehensive Federal nonnuclear energy research, development, and demonstration program which will expeditiously advance the policies established by this Act and other relevant legislation establishing programs in specific energy technologies . , ,"

Critique: Present ERDA management practices have three recognizable flaws. These could serve as serious drawbacks to the agency's effective implementation of the R, D&D program.

The problems are as follows:

- Internal project management tends to impose excessively detailed restrictions on R, D&D programs;

- Project management delegated to outside agencies or firms has been awarded to organizations having excessively detailed management structures. The result has been a loss of ERDA program control;

- Systems analysis—an important tool—has been used excessively in lieu of actual, experimental testing of the feasibility of technologies,

At this early stage of ERDA's development, these difficulties could be easily remedied. As a new agency, ERDA has excellent opportunities to benefit from the experiences of older groups and to adopt up-to-date management procedures and techniques.

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.

The R, D&D Act: Sec. 5(a)(5): "The potential for production of net energy by the proposed technology at the stage of commercial application shall be analyzed and considered in evaluating proposals."

Critique: Net energy analysis is used to determine the quantity of energy that is needed to produce energy. For instance, to produce shale oil, a certain amount of energy must be used to mine, transport, and heat the shale.

This analytical technique can aid in evaluating the potential of various energy technologies. However, a great deal of research is needed before it can be a consistent and widely accepted method.

The ERDA Plan does not address the problems with respect to the "net energy" approach or establish criteria for its use.

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