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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D.C. 20548

B-202377

MARCH 23, 1981

The Honorable Marilyn Lloyd Bouquard
Chairman, Subcommittee on Energy
Research and Production
Committee on Science and Technology
House of Representatives


115038

Dear Madame Chairman:

Subject: Department of Energy Light Water Reactor Fuel Utilization Improvement Program (EMD-81-51)

DOE

On May 2, 1980, the former Subcommittee Chairman requested that we evaluate two Department of Energy nuclear research and development programs. One is a program to improve fuel utilization in light water reactors, and the other is the Department's light water breeder reactor program. This report presents the results of our evaluation of the light water reactor fuel utilization program, with emphasis on the reasonableness of the Department's goals, progress in meeting the goals, and what, if any, technical or regulatory problems need to be resolved. A report on the light water breeder reactor program will be issued separately.

The original goals of the fuel utilization program were to demonstrate nuclear fuel saving improvements by 1988 that would permit utilities to reduce fuel requirements by 15 percent and to demonstrate further improvements by 2000 that could result in an additional 15 percent fuel savings. When the Department set up the program it estimated that these savings, if realized, could extend the Nation's uranium reserves by 5 to 8 years. DOE has now dropped further consideration of its goal for the year 2000.

The Department's program is still at an early stage; therefore, only limited program results are available. However, based on our discussions with Department and nuclear utility officials, nuclear fuel suppliers, and private sector organizations funding complementary work, as well as our review of available technical studies, correspondence, and other documents, we concluded that:

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--The Department's 1988 goal is reasonable. Much of the Department's short-term demonstration program consists of proving that existing fuels can be used longer and working on new fuel savings designs and other improvements.

--How extensively the commercial nuclear industry will implement fuel savings improvements is uncertain at this time. Many utilities will probably use the Department's major short-term improvement, longer burnup fuel, to accomplish their own economic objectives of minimizing power generation costs at the expense of maximizing fuel savings. With longer burnup fuels, utilities have the options of either (1) refueling their reactors at traditional intervals, but replacing less fuel; or (2) lengthening the time between refueling shutdowns. The former will optimize fuel savings. The latter will reduce the number of times reactors must be shut down for refueling, resulting in large replacement power cost savings.

--The Department's program is adequately structured to identify and resolve technical and regulatory problems related to the specific demonstrations now underway. A draft study assessing potential regulatory issues has concluded that there are no regulatory problems which might preclude the widespread use of the Department's short-term improvements.

--The Department's program will not foreclose a future option of reprocessing light water reactor spent fuel and recycling recovered uranium and plutonium, or of deploying breeder reactors. Some specific fuel improvements, however, are expected to be at best only marginally attractive with reprocessing and recycling.

In summary, the key to the success of the Department's program is industry implementation. While there are incentives for implementation, many utilities will probably continue to pursue their own economic objectives at the expense of maximum nuclear fuel savings. Thus, it is unlikely that the Department will realize its fuel savings goals in an absolute sense, if the present trend toward longer intervals between refuelings continues. To date, the Department has made little effort to identify how extensively utilities may use these improvements to save fuel. In selecting future projects, the Department should emphasize those with greater prospects for achieving fuel savings through industry acceptance.

Even with widespread nuclear industry implementation, the Department's program will only extend the Nation's uranium reserves a few years. Thus, at best, the program can only postpone the inevitable decision either to employ fuel reprocessing and recycling technology with light water reactors and/or breeder reactors as an integral part of a long-term nuclear strategy or decide that nuclear power will play only a short-term role in which fuel reprocessing and recycling is not needed. Until this policy question is finally decided, the Department should defer developing improvements which are only marginally attractive with reprocessing and recycling.

All of these issues are discussed in more detail in Enclosure I. Enclosure II discusses our evaluation objectives, scope, and methodology.

As your office requested, we did not obtain official comments on this report from the Department of Energy.

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As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of the report. At that time, we will send copies to interested parties and make copies available to others upon request.

Sincerely yours,

Milton J. Socolar

Acting Comptroller General
of the United States

EVALUATION OF THE DEPARTMENT OF ENERGY'S NUCLEAR FUEL USE IMPROVEMENT PROGRAM

BACKGROUND

Today, there are 69 commercial nuclear powerplants operating in this country and another 100 plants under construction or planned. All but one of these plants are water-cooled reactors, usually referred to as light water reactors.

About 4 years ago, the Energy Research and Development Administration 1/ began a demonstration program aimed at making more efficient use of the energy potential in light water reactor fuel--historically, these reactors have used only 1 to 2 percent of the energy potential in the uranium fuel. The Department of Energy (DOE) expanded this program to demonstrate increased reactor fuel efficiency by 15 percent by 1988. By the year 2000, DOE hoped to demonstrate additional improvements that can permit utilities to increase fuel efficiency by another 15 percent. Successful demonstration and implementation could, according to DOE, extend the life of the Nation's uranium resources by 5 to 8 years. DOE has now dropped, however, further consideration of the long-term goal.

DOE's current emphasis is on demonstrating fuel saving improvements which can readily be used in plants now operating and under construction. The principal improvement projects are to demonstrate that current fuels can be burned longer and that future fuels of different designs can be burned still longer. Utilities and nuclear fuel suppliers are participating in the demonstration program on a cost sharing basis under contracts with DOE. Each participating utility works with a nuclear fuel supplier on major demonstration projects conducted in licensed nuclear powerplants with Nuclear Regulatory Commission (NRC) approval prior to demonstration. In conjunction with these demonstration projects, DOE also contracts with laboratories and other institutions for supporting studies and analyses and for experiments conducted in test reactors.

1/The Energy Research and Development Administration was one of the agencies incorporated into the Department of Energy when the Department was established on Oct. 1, 1977.

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This year DOE plans to spend about $20 million on this program. To date, about 80 percent of the budget has gone toward researching, developing, and demonstrating techniques for burning fuel longer in reactors. If DOE is successful, utilities may be able to burn fuel in reactors as long as 5 years, instead of the current 3 year period. Longer burnups have the greatest short-term fuel savings potential and make up about 11 percent of the first 15 percent of improvements to be demonstrated by 1988. Over the next 5 years, DOE plans to spend roughly two-thirds of its program funds on longer burnup fuel projects.

Because DOE's program is at an early stage, only limited program results are available at this time. Therefore, our basic evaluation approach was to canvas the nuclear industry and review published literature to answer the following questions:

--Are DOE's goals reasonable from a technical demonstration standpoint?

--Has DOE identified the technical and regulatory impediments to potential fuel savings improvements and initiated or planned steps to resolve them?

--Are utilities and nuclear technology suppliers likely to implement the improvements DOE is demonstrating?

--Will successful demonstration and implementation of DOE's program foreclose the use of reprocessing and breeder reactor technologies?

The following sections answer these questions.

DOE'S SHORT-TERM GOALS ARE REASONABLE FROM A TECHNICAL DEMONSTRATION STANDPOINT

DOE's short-term goal is to demonstrate fuel saving improvements by 1988 that will permit utilities to increase fuel efficiency by 15 percent. The utilities and reactor fuel suppliers we contacted agreed that, from a demonstration standpoint, the short-term goal is reasonable.

DOE contracted with Combustion Engineering, Inc., a nuclear reactor manufacturer and nuclear fuel supplier, to study potential fuel savings improvements for pressurized water reactors. In its April 1980 report, the contractor

concluded that a 21-percent reduction in the 30-year lifetime uranium ore requirements for a pressurized water reactor could be achieved by fully implementing fuel saving improvements which can be demonstrated by 1988. Pressurized water reactors comprise about two-thirds of the light water reactors in this Nation. A similar study addressing boiling water reactors--the other type of conventional light water reactor--prepared for DOE by the General Electric Company estimated potential uranium ore savings of 10 to 20 percent in the short term and 20 to 30 percent in the long term.

The nuclear utilities and all five of the U.S. nuclear fuel suppliers we contacted agreed that DOE's short-term goal of 15 percent is realistic. Several reasons were given to support this view.

--The specific fuel saving improvements to be demonstrated are well defined.

--Some of these improvements are extensions of technologies now in use, rather than new technologies.

--DOE is accelerating development and demonstration of some improvements which the nuclear industry was already developing at a slower pace.

--Some fuel savings improvements involve changes in nuclear fuel management schemes and powerplant operating methods rather than hardware changes.

DOE IS IDENTIFYING AND ATTEMPTING TO RESOLVE TECHNICAL AND REGULATORY PROBLEMS

Utilities, nuclear fuel suppliers, NRC, and other nuclear industry officials we talked to generally agreed that DOE's program is adequately structured to identify and resolve technical and potential regulatory problems. Presently, there do not appear to be any major regulatory problems which might preclude widespread utility use of fuel savings improvements. The major regulatory test, however, will not come until the first few utilities request approval for large-scale demonstration or full implementation of major improvements.

As stated previously, DOE's major short-term improvement is to demonstrate fuels which can be burned longer in reactors. Several major technical problems must be resolved

before utilities can confidently implement DOE's plans for longer fuel burnup. One problem, known as fuel pellet-cladding interaction, relates to the potential for increased failure of fuel rods once fuel pellets come in contact with the cladding surrounding them. A second problem is the potential for excessive internal pressures in fuel rods due to increases in the quantity of gases generated by nuclear fission. Longer burnups increase the risks of fuel rod failures from both of these technical problems unless measures are taken to remedy them.

Utility interest in solving pellet-cladding interaction problems precedes DOE's program. According to the Electric Power Research Institute, the problem is primarily responsible for current NRC operating restrictions on boiling water reactor operations which utilities estimate cost them over $150 million annually. Industry and Government research on the problem has been underway since the early 1970s.

DOE currently has two projects underway in boiling water reactors to demonstrate advanced fuel designs resistant to pellet-cladding interaction. According to nuclear fuel suppliers, the projects' results could also be extended to pressurized water reactors. Demonstration results, however, are not likely to be available until about the middle of the decade. Although DOE officials do not anticipate any problems, slippage in these projects could adversely affect DOE's ability to achieve its short-term program goal.

Resolving the fission gas problem is also critical to the technical success of DOE's program. As fuel burnup increases the fission gas release rate increases, but the space to accommodate the gases decreases. Advanced fuel designs using hollow fuel pellets increase fission gas space and lower fission gas releases. Fuel pellets fabricated from uranium dioxide of a larger grain size than conventional fuel also reduce fission gas release. DOE is currently testing fuel from some advanced designs in two nuclear powerplants. DOE plans to complete these demonstration projects and subsequent laboratory analyses by the middle of the decade.

Each demonstration project in an operating nuclear powerplant is reviewed and approved beforehand by NRC. NRC's review and approval are a part of its routine evaluation of utility fuel management and refueling activities. According to NRC officials, the small-scale demonstration projects already underway were approved because their potential effects on safety were minimal. Because the planned fuel saving improvement projects were extensively analyzed

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and subjected to out-of-reactor testing, NRC was able to conclude that its demonstration would not limit the power-plants' response capabilities because of an accident or other abnormality.

If demonstration projects in commercial reactors on a larger scale are successful, DOE hopes utilities will seek NRC's approval for full implementation of the improvements. To prepare for the larger-scale demonstration projects and subsequent implementation, DOE has contracted with Combustion Engineering, Inc., for a study identifying potential regulatory issues and determining whether additional research, development, or demonstration projects will be required to resolve them. A current draft of the nearly completed study concludes that there are no major regulatory issues which might preclude the widespread use of longer burnup fuel and other short-term fuel savings improvements. The study also identified areas where additional research, development, and demonstration projects may be needed to increase NRC's and utilities' confidence in longer burnup fuels. After incorporating industry comments, DOE plans to submit the study to NRC for review and comment. NRC officials familiar with the details of DOE's short-range program did not foresee any major regulatory impediments to eventual utility implementation if DOE can satisfactorily resolve the major technical issues discussed above.

DOE's efforts to anticipate future regulatory issues in demonstration projects may not be seriously tested until NRC's approval is requested for a large-scale or full-core demonstration. At that time, NRC may have to broaden its present incremental safety analysis of demonstration projects to something similar to the fuel-related portions of the safety evaluation it performs prior to initially licensing plant operations. For example, NRC may require analyses of fuel responses to a range of possible accident conditions. Furthermore, such analyses would be done on a plant-by-plant basis as utilities implement major fuel savings improvements.

At present, no one is sure how new plant-by-plant NRC fuel-related safety analyses might affect industry implementation of fuel saving improvements. DOE expects that the NRC review of the first full-scale demonstration may take somewhat longer than its current reviews of utility refueling activities. DOE believes, however, that subsequent approval requests for similar demonstrations and/or implementation would become routine.

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IMPLEMENTATION OF DOE'S FUEL SAVING IMPROVEMENTS IS UNCERTAIN

The key to the ultimate success of DOE's program is the extent to which utilities and nuclear fuel suppliers use the improvements DOE demonstrates. No matter how many fuel saving improvements DOE successfully demonstrates, it will not realize its fuel saving goals unless utilities and nuclear fuel suppliers implement them as DOE anticipates. While there are incentives for utilities to use such improvements, there are also strong economic incentives for implementation in a way which results in less than demonstrated fuel savings. Utilities may use some fuel improvements to lengthen the interval between powerplant refuelings, which results in increased fuel consumption.

By implementing DOE's fuel savings improvements, utilities could, over the long run, reduce the quantity and costs of both fresh nuclear fuel and spent fuel storage and (eventually) disposal. DOE believes these are strong incentives for utilities to use fuel saving improvements.

In making fuel management decisions, however, utilities also consider other factors besides fuel savings and fuel cycle costs. The major one is the cost of power to replace that lost when a nuclear powerplant is shut down for refueling. Others include regulatory and powerplant maintenance requirements. In making nuclear fuel management decisions, utilities are likely to go with the most economical choice, a choice which may differ widely among individual utilities depending on the net cost of replacement power to each.

In a typical pressurized water reactor about one-third of the fuel is replaced approximately every 12 months, and in a boiling water reactor about one-fourth of the fuel is replaced approximately every 18 months. If successfully demonstrated, longer burnup fuel will enhance two basic nuclear fuel management options utilities now have. First, a utility could maintain the traditional operating period but replace less fuel at each refueling--the option yielding the greatest uranium savings. Second, a utility could extend its powerplant operating period by about 6 months and continue to replace about the same amount of fuel at each refueling outage as it traditionally has. This would reduce the fuel savings achievable from longer burnup fuel, because higher levels of enrichment in the fissionable uranium isotope would be required; but it would increase the time the powerplant is available to produce electricity. DOE expects utilities to achieve an 11-percent fuel savings whenever operating cycles are unchanged. This projection is the

cornerstone of DOE's short-term program goal. In practice, however, many utilities are already making these cycles longer. A utility which implements this improvement while lengthening its cycle obtains much less fuel savings--as little as 4 percent.

There is already a strong trend towards longer powerplant operating periods to increase plant availability due to the high cost of replacement power. An Electric Power Research Institute comparison of potential nuclear fuel cost savings versus increased plant availability showed that electrical generating cost savings from less than three days (65 full power hours) of increased powerplant availability could offset the cost savings possible from maximizing fuel savings. Some utilities have already adopted longer operating cycles, and others are planning such cycles. The Virginia Electric Power Company, for example, recently changed its pressurized water reactor refueling strategy. Instead of replacing one-third of the fuel in each of its reactors at 12 month intervals, the company plans to replace about one-half of the fuel every 18 months. The decision was based on the utility's cost analysis showing the switch could save the Company $30 million a year for the next 3 years.

The nuclear fuel suppliers told us that they supply utilities with refueling cost estimates for both traditional and longer fuel cycles. Combustion Engineering, Inc., and the Babcock and Wilcox Company expect nearly all of their utility customers to lengthen operating cycles during the mid- to late-1980s. There may, however, be at least one potential impediment to some utilities shifting to longer operating cycles--NRC may require that some nuclear powerplants be shut down for periodic maintenance at shorter periods. Minimizing total down time for these plants may mean refueling them when they are shut down for the required maintenance.

In focusing its short-term program on longer burnup fuel, DOE realized that utilities might use this improvement to emphasize powerplant availability over increased fuel savings. DOE points out that utilities should nonetheless realize some fuel savings--on the order of 4 percent--even when they emphasize powerplant availability.

DOE'S PROGRAM WILL NOT FORECLOSE USE OF REPROCESSING AND BREEDER REACTOR TECHNOLOGIES

From nuclear power's beginning, it was expected that finite uranium resources would be extended by (1) reprocessing light water reactor spent fuel and recycling the recovered uranium and plutonium into refabricated fuel and (2) deploying plutonium-fueled breeder reactors which would produce more plutonium than they consumed. Plutonium, however, is also a nuclear weapons material. Concern over the potential worldwide proliferation of plutonium-based nuclear fuels, coupled with projections of reduced growth in electrical energy demands and discoveries of larger uranium reserves, led the previous administration to indefinitely defer spent fuel reprocessing and breeder reactor commercialization.

DOE's fuel saving improvement program was a key element in the previous administration's strategy for implementing its policies of indefinitely deferring spent fuel reprocessing and recycling and the use of breeder reactors. If nuclear fission power is to be a long-term energy option, however, a decision to develop reprocessing technology and breeder reactors is inevitable. Thus, an important consideration in selecting projects for demonstration is whether they might adversely affect the Nation's future ability to employ these technologies.

Studies performed for DOE conclude that, on balance, DOE's program does not technically or economically foreclose the options of using spent fuel reprocessing and recycling or of deploying breeder reactors. Some minor individual fuel saving improvements, however, are expected to be only marginally attractive in light water reactors with reprocessing and recycling.

Compatibility of DOE's fuel improvements with reprocessing and recycling

Studies performed for DOE generally concluded that DOE's fuel saving improvement program would not foreclose the option of reprocessing spent fuel and recycling the recovered uranium and plutonium into new fuel. Combining longer burnup fuel and certain other elements of DOE's fuel saving program with reprocessing and recycling would make less efficient use of uranium resources than reprocessing and recycling without DOE's program. For other program elements, more efficient use of uranium would result. According to DOE, any resource efficiency penalties could be more than offset by economic gains

realized because of reduced reprocessing and recycling requirements. Using its current pressurized water reactor fuel design, Combustion Engineering, Inc., assessed the impact of DOE's short-term and selected long-term fuel saving improvements on reactors assumed to be operating with reprocessing and recycling. Based on a 30-year reactor life, the Company concluded that:

--Incorporating all short-term fuel savings improvements which are technically compatible with reprocessing and recycling would only slightly extend the uranium resource savings.

--Some short- and long-term fuel saving improvements would not be economically attractive until the price of uranium increased from about $40 per pound to about $100 per pound (a price at which reprocessing and recycling might become economically competitive with a once-through fuel cycle).

--Some improvements which could save fuel resources in a once-through fuel cycle would, when used with reprocessing and recycling, result in less uranium resource savings than would be attainable with reprocessing and recycling without the improvements. Despite this penalty, these improvements might be used with reprocessing and recycling because they would (1) reduce the volume of spent fuel to be stored and reprocessed by up to 40 percent and (2) reduce uranium-plutonium fuel refabrication requirements. Savings in these relatively expensive fuel cycle steps would probably more than offset the fuel resource penalty.

The General Electric Company also evaluated the potential impacts of DOE's program on boiling water reactors operating with reprocessing and recycling. The Company concluded that a number of potential improvements are not only compatible with reprocessing and recycling but could also extend uranium resource savings.

Compatibility of DOE's fuel saving improvements with breeder reactors

Because breeder reactors produce more fuel than they consume, they offer a long-term solution to the Nation's energy problem. By breeding, reprocessing, and recycling recovered fuel into breeder reactors, nuclear energy could be a major electrical energy source for centuries.

Moving from light water reactors to deployment of breeder reactors requires an initial inventory of plutonium sufficient to fuel breeders until they can breed enough plutonium to refuel themselves. Full implementation of DOE's fuel saving program will reduce the quantity of plutonium produced in light water reactors but, according to DOE, would not preclude this Nation from starting a self-sustaining breeder reactor program. DOE reasons that a sufficiently large quantity of plutonium already exists in the spent fuel now in storage to easily meet initial breeder reactor fuel requirements. In addition, more plutonium will be produced in the future by light water reactors now operating and under construction.

Utility use of DOE's fuel saving improvements would reduce the quantity of plutonium produced by light water reactors, but the concentration of plutonium in spent fuel would be higher than in spent fuel not being produced. Combustion Engineering and DOE officials say this will reduce the cost of reprocessing spent fuel and recycling the plutonium into fresh breeder reactor fuel. DOE also maintains that with implementation of its fuel savings improvements, light water reactor spent fuel should contain slightly larger quantities of the plutonium isotope most conducive to breeding.

CONCLUSIONS

The key to the ultimate success of DOE's program lies in utility implementation rather than technical demonstration. DOE will probably be able to achieve its short-term goal of demonstrating by 1988 fuel saving improvements which, if implemented, would permit utilities to reduce nuclear fuel requirements by about 15 percent providing each utility keeps its nuclear plants operating at their present operating cycles. The extent and manner in which utilities and nuclear fuel suppliers will implement these fuel saving improvements, however, is largely uncertain. In making nuclear fuel management decisions, utilities must weigh many factors and make a number of trade-offs to arrive at the most economical course of action. One such trade-off is the cost of fuel versus minimizing the frequency with which powerplants are down for refueling. Many utilities will probably continue on their present trend to increase the time their nuclear powerplants are available to generate electricity, thereby reducing their overall electrical generating costs, at the expense of most efficient use of nuclear fuel. Although some fuel savings can still be achieved if this continues, over one-half of the net fuel savings might be lost. In the future, therefore, DOE

should be careful to consider how the nuclear industry will implement fuel saving improvements in deciding which improvement options to demonstrate.

To a large extent, DOE's short-term program is an extension of existing technology and/or an acceleration of ongoing industry research and development work. DOE has identified major technical and regulatory problems and has taken or planned steps to resolve them. The major regulatory-related test, however, will not come for several years until a utility requests NRC approval for a large-scale demonstration project or to fully implement major fuel saving improvements.

Studies performed for DOE by its contractors conclude that, on balance, DOE's program does not foreclose the options of using spent fuel reprocessing and recycling or of deploying breeder reactors. Some minor individual fuel saving improvements, however, are expected at best to be only marginally attractive with reprocessing and recycling. DOE should defer developing such marginally attractive options until a final decision is made on reprocessing and recycling policy to ensure that it does not spend funds on improvements which may not be implemented.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

To preclude spending funds on fuel saving improvements having little likelihood of implementation, or which may be implemented in ways that do not achieve fuel savings, we recommend that the Secretary of Energy

--carefully consider the prospects for industry implementation to achieve maximum fuel savings, and give priority to those improvements which offer both the highest fuel savings and the best chance of implementation to achieve those savings; and

--defer spending research and development funds on fuel saving improvements which are at best only marginally attractive with reprocessing and recycling until a final policy decision is made on reprocessing and recycling policy.

OBJECTIVES, SCOPE, AND METHODOLOGY

On May 2, 1980, the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology asked us to evaluate DOE's light water reactor fuel utilization program with emphasis on the reasonableness of DOE's goals, progress in meeting the goals, and what, if any, technical or regulatory problems need to be resolved. Subsequently, the Chairman's office requested that we also assess the program's potential impact on the possible future use of nuclear fuel reprocessing and breeder reactors.

Because DOE's program is at an early stage, only limited program results are available at this time. Therefore, our basic evaluation methodology was to canvas the nuclear industry and review published literature to obtain an understanding of industry attitudes toward the Department's program including its specific goals and objectives. We relied principally on studies, technical reports, and other documentation on the subject of improving fuel use efficiency in light water reactors as valid indications of the technical feasibility of achieving program goals. We also had discussions with the five U.S. nuclear fuel suppliers, four utilities participating in DOE's program, and DOE and NRC officials. A complete list of who we contacted in addition to DOE and NRC appears at the end of this discussion. The principal studies we used in preparing this report were performed under contract to DOE by nuclear fuel suppliers. These studies were intended to provide DOE with the scientific and engineering information base needed to (1) determine the technical feasibility of achieving program goals and (2) identify potential technical and licensing problems. The studies do not, however, address the question of utility implementation. For this information we principally relied on the utilities, nuclear fuel suppliers, and other industry-related groups. We also used all of these organizations to test the reasonableness of DOE's goals and the adequacy of its program in identifying and resolving technical and regulatory problems.

It is too soon in DOE's program to determine with complete confidence how, and in what manner, the nuclear industry will implement demonstrated improvements. Because the program's success depends on utility and nuclear fuel supplier implementation, however, we considered these organizations as the most reliable source of information on implementation. Therefore, we believe this report

contains a realistic current assessment of the nuclear industry's views on how implementation will likely occur.

DOE funded studies conducted by nuclear fuel suppliers were the only studies available which addressed in any detail the extent to which DOE's fuel saving improvement program might technically or economically foreclose the future use of reprocessing and recycling technologies and breeder reactors. Our work on this question was limited to a review of the studies supplemented by discussions with DOE officials and representatives of the fuel suppliers.

Nuclear fuel suppliers

Babcock and Wilcox
Combustion Engineering, Inc.
Exxon Nuclear Company, Inc.
General Electric Company
Westinghouse Electrical Corporation

Utilities

Arkansas Power and Light
Duke Power Company
Tennessee Valley Authority
Virginia Electric Power Company

Others

American Nuclear Energy Council
Edison Electric Institute
Electric Power Research Institute