UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY, AND ECONOMIC DEVELOPMENT DIVISION

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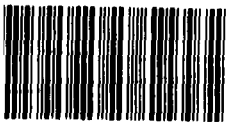

The Honorable Richard L. Ottinger
Chairman, Subcommittee on Energy
Conservation and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

Subject: DOE Needs to Evaluate Fully the Waste Management Effects of Extending the Useful Life of Nuclear Fuel (GAO/RCED-84-111)

In your letter of September 22, 1983, you expressed concern that the Department of Energy (DOE) may be overlooking or, at least, not fully utilizing opportunities available under its Light Water Reactor Extended Burnup program to help fulfill the Department's responsibilities under the Nuclear Waste Policy Act of 1982.[1] This letter summarizes our efforts to determine whether DOE needs to do more to evaluate the potential impact of "extended fuel burnup" on its planning efforts to carry out the act.

The Nuclear Waste Policy Act of 1982 established a comprehensive national program for the interim storage, and permanent disposal, of spent fuel[2] discharged from commercial nuclear power reactors. Although comprehensive in stipulating how spent fuel will be managed, the act does not contain provisions designed to encourage reduction in the amount of spent fuel generated by reactors. However, a relatively small DOE effort ($4.5 million in fiscal year 1984) has the objective of reducing substantially the generation rate of spent fuel. This DOE effort--referred to as the extended burnup program--supports research and development projects to extend the "burnup" or useful life of

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[1]Public Law 97-425, 96 Stat. 2201, 42 U.S.C. 10101 et. seq.

[2]Spent fuel is fuel that has been "burned" in a nuclear reactor to the point where it no longer contributes efficiently to the nuclear chain reaction and must be replaced.

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nuclear fuel in the predominant type of commercial nuclear powerplants, called light water reactors. As you know, the administration in recent years has been trying to phase out the extended burnup program, but the Congress has continued to fund the program at a level to prevent termination of existing contracts and provide the continued involvement of all five U.S. fuel manufacturers. For the last 2 fiscal years the administration has viewed the extended burnup program as one that should be left to the private sector under the administration's policy of minimizing federal expenditures in research and development activities with near-term benefits.

Extended burnup of nuclear fuel provides a potential opportunity to reduce future spent fuel inventories and the requirements for government facilities and services to accommodate the spent fuel. While the magnitude and timing of the reductions are uncertain, DOE has found that up to a 40 percent annual reduction in the rate of spent fuel generation is possible. Accordingly, we are making recommendations to the Secretary, DOE to complete a full evaluation of the potential to extend fuel burnup and the effects on DOE's program for accepting commercial spent fuel for safe management, storage, and disposal.

A related issue which we addressed in a November 1981 report,[3] concerned the future role the government should play in furtner research and development to extend the use of nuclear fuel. We stated that

> "Any future decisions on phasing out or continuing the program--and if so, at what level of funding--should carefully consider (1) the potential budgetary costs, (2) the potential benefits and beneficiaries, and (3) the probability that the nuclear industry will not be able to continue the program at a pace consistent with the Department's current schedule."

We further stated that

> "Certainly, the potential benefits of the program raise a question about whether the program should be dismissed simply because it may not fall among the high-risk, long-term research programs being given priority under the new administration's energy policy."

In that report we focused on the potential economic benefits to utility rate payers and found them substantially greater than the cost of continuing the program. Although we did not discuss the possible implications, we noted several potential benefits of

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[3]The Costs and Benefits of Alternative Funding Levels for the Department of Energy's Light Water Reactor Improvement Program (EMD-82-16, Nov. 18, 1981).

the extended burnup program, including that, if successful, the program could lead to "less spent fuel to store and eventually dispose of as spent fuel or reprocessed high-level wastes." Given the subsequent passage of the Nuclear Waste Policy Act and the responsibilities of DOE to provide disposal and possibly spent fuel storage services to utilities under now clearly defined circumstances, the significance of the rate and extent higher burnup fuels are used by utilities, in our opinion, takes on added importance from a possible government support standpoint.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of our work was to determine whether DOE needs to do more to evaluate the potential impact of extended nuclear fuel burnup on its program for accepting commercial spent nuclear fuel under the Nuclear Waste Policy Act. To determine the relationship between extended burnup and waste management, we reviewed studies by DOE and independent analysts which discuss the implications of extended burnup for waste management. To ensure that we identified as complete a list of existing studies as possible, in addition to our own research efforts, we contacted representatives of DOE, the Nuclear Regulatory Commission, the five principal U.S. fuel manufacturers,[4] utilities,[5] and utility and nuclear industry organizations.[6]

For specific information regarding DOE's extended burnup program and waste management activities, we reviewed DOE program documents and congressional hearing records. We also interviewed DOE's Director of Light Water Reactor Projects and several officials within the Office of Civilian Radioactive Waste Management, including the Office's Acting Deputy Director. In addition, we relied on information obtained from two of our previous reports on the extended burnup program[7] and during our ongoing annual

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[4]Babcock and Wilcox; Combustion Engineering, Inc.; Exxon Nuclear Company, Inc.; General Electric Company; and Westinghouse Electric Corporation.

[5]Duke Power Company, Florida Power and Light Company, and Virginia Electric Power Company.

[6]Atomic Industrial Forum, American Nuclear Energy Council, American Nuclear Society, Edison Electric Institute, and Electric Power Research Institute.

[7]Department of Energy Light Water Reactor Fuel Utilization Improvement Program (EMD-81-51, Mar. 23, 1981), and The Costs and Benefits of Alternative Funding Levels for the Department of Energy's Light Water Reactor Improvement Program (EMD-82-16, Nov. 18, 1981).

audit of DOE's Office of Civilian Radioactive Waste Management mandated under the Nuclear Waste Policy Act of 1982. We conducted this work during October and November 1983.

In early January 1984, we reviewed our work in light of DOE's releasing on December 23, 1983, the first volume of a working draft of a "Mission Plan". This plan was being prepared to define how DOE plans to carry out the requirements of the Nuclear Waste Policy Act. The draft was provided to representatives of other federal agencies, Congress, state governments, Indian tribes, and utility and nuclear industries for review and comment in advance of the time required by the act for formal draft comment (April 7, 1984) and formal submission to the Congress (June 7, 1984). To meet the time frame for information requested by your office, we limited our review of this plan to determining whether it considered the potential effect of utilities extending fuel burnup on DOE's commitment to begin accepting commercial spent nuclear fuel for eventual permanent disposal in 1998.

At the request of your office, we did not obtain official agency comments on this report. We did, however, discuss with DOE officials their plans for gathering further information to evaluate the waste management effects of extended burnup. Except for not obtaining agency comments, this review was performed in accordance with generally accepted government auditing standards.

LINK BETWEEN EXTENDED BURNUP OF NUCLEAR FUEL AND WASTE MANAGEMENT

DOE's extended fuel burnup program focuses on improving the fuel use of commercial nuclear powerplants. Historically, light-water reactors have used only 1 to 2 percent of the energy potential in nuclear fuel before it is removed. To make more efficient use of this fuel, DOE has been conducting various research and development activities. One effort has been a program to extend the time fuel is used in the reactor. The longer the fuel remains in a reactor before removal, the higher the "burnup" or cumulative amount of energy produced by that fuel. The process of using the fuel more efficiently by leaving it in a reactor longer is referred to as "extended burnup" or "high burnup."[8]

From a waste management perspective, extended burnup is important because the amount of spent fuel discharged from a

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[8]The length of use or "burnup" of fuel in a reactor is measured in terms of megawatt days per metric ton of uranium (Mwd/mtu), a measurement of the amount of energy generated over time by uranium fuel. For typical commercial power generation, fuel is removed from reactors after 3 to 5 years with cumulative burnup levels of 28,000 to 34,000 Mwd/mtu.

nuclear powerplant is generally inversely proportional to fuel burnup. Accordingly, extended burnup has the potential for reducing the rate spent fuel is discharged from nuclear powerplants. This potential reduction is important in view of the anticipated growth in spent fuel inventories. Based on the latest available information,[9] DOE estimated that under current typical fuel burnup levels the total amount of spent fuel discharged from nuclear powerplants up to the end of calendar year 1982 will double by 1989, triple by 1992, and quadruple by 1996. By 2020, DOE projected that almost 15 times more spent fuel could be discharged than was in 1982.

Most spent fuel is currently stored in water-filled pools at the sites of nuclear power reactors. This was intended to be a temporary measure until commercial facilities became available to chemically reprocess the spent fuel to recover reusable materials. However, past efforts to develop commercial reprocessing have not been successful and there are no firm industry plans to do so. Because spent fuel contains highly radioactive materials which remain potentially dangerous for thousands of years, DOE is preparing to permanently dispose of spent fuel in the form in which it comes from a reactor in stable rock formations--called geologic repositories--about half a mile beneath the surface. Under contracts entered into with the nation's utilities following passage of the Nuclear Waste Policy Act, DOE must begin accepting title to commercial spent fuel (or "high-level wastes" from a reprocessing facility) after the start of repository operations but not later than January 31, 1998. As an option for meeting this commitment, DOE is also preparing plans for construction of a storage facility, referred to as monitored retrievable storage, in the event there is a significant delay in the start of repository operations.

In the meantime, utilities are responsible for their own interim storage of spent fuel. The Nuclear Waste Policy Act, as a matter of policy, requires the government to "encourage and expedite the effective use of existing storage facilities." It specifically establishes a cost-sharing program with utilities to demonstrate advanced spent fuel storage technologies to help expand existing utility storage capacity. Moreover, the act requires DOE to provide limited federal storage capacity in the event that a utility lacks sufficient storage space after the Nuclear Regulatory Commission first determines all "reasonable" attempts by the utility have been made to provide for its own needs.

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[9]Mid-case spent fuel generation projection contained in Energy Information Administration (EIA) memorandum on EIA Projections of Nuclear Power Capacity through 2020 and Associated Electricity Generation and Spent Fuel Arisings, Sept. 19, 1983.

The extended burnup and commercial radioactive waste management programs are managed by separate offices within DOE. Under the Assistant Secretary for Nuclear Energy, the Division of Light Water Reactor Projects in the Office of Converter Reactor Deployment is responsible for developing and demonstrating extended burnup. The Office of Civilian Radioactive Waste Management is responsible for carrying out the Nuclear Waste Policy Act under a direct organizational and reporting relationship to the Secretary of Energy as required by the act. The commercial radioactive waste management program has been a high priority DOE effort since the act's enactment in January 1983. In contrast, DOE is planning on phasing out the extended burnup program and is not expected to request any further funding from the Congress.

EVOLUTION OF DOE'S LIGHT WATER REACTOR EXTENDED BURNUP PROGRAM

Federal activities to develop and demonstrate extended burnup were initiated in fiscal year 1976 as a program with emphasis on uranium conservation. The original focus of the program was to demonstrate certain technologies that could lower the uranium fuel requirements of light water reactors. The Light Water Reactor Improvement program--consisting primarily of activities to promote extended burnup--was a major feature of the Carter administration's nuclear energy policy.

As noted in our November 1981 report on the program, the current administration adopted a policy of funding only long-term, high-risk research programs and began phasing out programs it believed should be supported by the private sector. As a result, executive branch support for extended burnup activities decreased. In fiscal year 1981 phase-out implementation began with the administration direction that no new contracts and no added financial commitments to then existing contracts for extended burnup activities would be allowed.

Subsequently, the Department narrowed the focus of its program by eliminating the development of fuel improvement technologies other than extended burnup and closely related fuel management activities. The program as refocused would demonstrate only those technologies that could be used in existing nuclear powerplants, are more likely to be implemented by the nuclear industry, and would reduce the volume of spent fuel generated by utilities. Program activities were designed to obtain data needed for licensing successively higher burnups of the nuclear fuel currently offered by all five domestic manufacturers as required by the Nuclear Regulatory Commission and for testing new advanced design fuel.

Through fiscal year 1983 DOE had spent about $73 million on its extended burnup program. Funding for the program peaked in fiscal year 1980 at about $18 million and subsequently declined to $11.5 million in fiscal year 1982 and $5 million in fiscal year 1983.

In fiscal year 1984 the executive branch requested no funds for the extended burnup program, but the Congress appropriated $4.5 million and directed DOE to maintain full industry participation in the program. In March 1983 DOE provided you information stating that the five U.S. fuel suppliers are offering burnup extensions in the range of 10 to 20 percent and that DOE anticipates all U.S. operating nuclear powerplants would take advantage of 20 percent burnup extensions during future refuelings within about 10 years. Further burnup extensions, DOE stated, are clearly within the capability of the private sector. In addition DOE noted that the prospects of lower utility storage requirements and disposal costs provide additional incentives to them to purchase higher burnup fuel.

However, it is uncertain whether industry will continue pursuing extended burnup. For example, the thrust of several different testimonies of nuclear industry representatives before congressional committees is that without continued DOE support, the schedule for realizing the potential benefits of extended burnup is likely to be slowed. Therefore, the extent and pace of progress beyond the burnup levels demonstrated by DOE are uncertain.

NEED FOR A FULL EVALUATION OF THE WASTE MANAGEMENT EFFECTS OF EXTENDED BURNUP

DOE has not conducted a full evaluation of the effects of utilities extending fuel burnup on national efforts to subsequently manage the higher burnup spent fuel that would be generated. Because of the relationship between increasing burnup--in terms of reducing the rate spent fuel is discharged from power reactors--and DOE's waste management activities under the Nuclear Waste Policy Act, we believe that DOE needs to conduct such an evaluation. This evaluation is needed regardless of whether DOE's extended burnup program is terminated because of the continuing trend of utilities extending fuel burnup levels.

DOE's research and development program has established that the burnup of light water reactor fuel in existing powerplants can be extended by at least 50 percent. This would result in an annual reduction in the generation rate of spent fuel, on an industry-wide basis, of 40 percent according to DOE's 1983 budget request. Such a large reduction could take decades to realize because of the time it takes to test, evaluate, and license fuels at higher burnup levels to ensure the fuel would not present a safety risk in the reactor. DOE's Director of Light Water Reactor Projects reported in 1982 that, under favorable conditions, widespread utility implementation of at least 50 percent greater burnup could be achieved in a series of four to five steps by 2000. One of the conditions identified was an aggressive research, development, and demonstration program.

Although this timing coincides with the 1998 date when DOE is obligated to begin accepting title to commercial spent fuel for eventual permanent disposal in a geologic repository, DOE has not yet factored even the 20 percent burnup extensions it anticipates within the next 10 years into its waste management planning. On December 23, 1983, DOE released for preliminary comment a proposed spent fuel acceptance schedule as part of a working draft of a Mission Plan on how DOE intends to carry out the Nuclear Waste Policy Act. The schedule specifies the total quantities of commercial spent fuel that DOE will accept on a yearly basis over a 29-year period beginning in 1998. DOE intends to update this aggregate schedule annually in response to the latest projections of nuclear power growth, and beginning in 1987 will include a priority acceptance ranking of spent fuel by individual utilities.

Because DOE's proposed spent fuel acceptance schedule does not consider the potential effect of utilities extending fuel burnups on reducing the generation rate of spent fuel, DOE may be overestimating the amounts of spent fuel it will be obligated to accept for permanent disposal at any given point in time and the requirements for needed government facilities and services to accommodate the spent fuel. According to the Acting Director of the Operations Division of DOE's Office of Civilian Radioactive Waste Management the data on individual utilities' actual and/or planned implementation of higher burnups is not yet available. He indicated this information, once it becomes available from the Department's Energy Information Administration (EIA), will then be evaluated to determine whether changes are needed in the acceptance schedule.

The working draft of the Mission Plan states that DOE does not intend to delay or postpone acceptance of commercial spent fuel even if a permanent geologic repository is not completed by 1998. As needed, DOE proposes making available by 1998 an acceptable storage facility to allow it to meet a firm acceptance schedule. This approach is designed to ensure that all utilities will be able to firmly plan for onsite interim storage needs until their spent fuel is accepted by DOE. The acceptance schedule will be designed so that the rate of acceptance in the first 5 years would be such that no utility will have to provide additional storage capacity after January 31, 1998. Subsequently, the acceptance rate would be set at a level equal to or greater than the actual generation rate of spent fuel each year.

It is likely that the Congress and others will use DOE's Mission Plan, when completed, as a major source of information on what will be done to solve the nation's problem of accumulating commercial spent fuel. The act requires DOE to complete a formal draft of the plan by April 7, 1984, and by June 7, 1984, to submit it to the Congress. Given that the spent fuel acceptance rate is such a key component of DOE's planning base for providing necessary storage and disposal facilities, as well as transportation and handling services, we believe DOE needs to specifically

quantify the potential effects of utilities extending fuel burnup in reducing the future size of spent fuel inventories. Otherwise, DOE may be planning on providing more facility capacity and services sooner than necessary. While extended burnup would not affect the size or timing of the first repository--since this is designated by the Nuclear Waste Policy Act--it could affect the size and timing of subsequent repositories.

In our opinion, identifying the specific waste management effects of extended fuel burnup will require DOE to develop (1) revised spent fuel generation projections and (2) an evaluation of the implications of extended burnup spent fuel on repository design. The spent fuel generation projections in the Mission Plan working draft do not consider continuing improvements in fuel burnup. The Office of Civilian Radioactive Waste Management has arranged for the EIA to develop scenarios of utility implementation of extended burnup and its effects in reducing the generation rate of spent fuel over more than a 4-decade period (1984 to 2026). This task will require EIA to modify the econometric model it uses to project spent fuel generation. EIA expects to complete this task in fiscal year 1984.

In addition, the impact of extended burnup spent fuel on the design of a permanent geological repository is not known. Because the fuel remains exposed within the reactor longer, extended burnup fuel is hotter than typical spent fuel and will remain so for thousands of years after discharge from the reactor, according to an October 1983 analysis by a DOE contractor. Initially, this effect might require a longer cooling period before the spent fuel is shipped offsite, thereby offsetting somewhat the lower storage requirements associated with a reduced amount of spent fuel. In the longer term, this effect might require the spent fuel to be emplaced in the repository at wider intervals and/or undergo further treatment or packaging which would add to disposal requirements. During our review, DOE officials informed us of preliminary discussions that were underway with a DOE contractor to conduct an evaluation of these potential effects of extended burnup on a waste repository. However, DOE officials were unable to make firm estimates as to when this work would be completed.

RECOMMENDATIONS

We recommend that the Secretary of Energy complete a full evaluation of the potential to extend fuel burnup and the effects on DOE efforts to subsequently manage the higher burnup fuel.

--DOE should consider the merits of continued government funding of the DOE extended fuel burnup program in terms of (1) the potential budgetary costs, (2) the potential benefits and beneficiaries, and (3) the likelihood that the nuclear industry would continue extending fuel burnup.

--DOE should quantify, to the extent possible, the effect of increases in fuel burnup on its spent fuel acceptance schedule, and clearly identify the potential impact on its requirements for providing the necessary facilities and services to carry out the Nuclear Waste Policy Act.

Furthermore, the Secretary should report the results of this evaluation to cognizant congressional committees (1) for their consideration of DOE's Mission Plan for carrying out the Nuclear Waste Policy Act and (2) as another factor for their fiscal year 1985 budget deliberations on whether to continue funding for DOE's extended burnup program.

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As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this letter until 7 days from the date it is issued. At that time we will send copies to the Secretary of Energy and make copies available to others upon request.

Sincerely yours,

J. Dexter Peach
Director