GAO

Report to Congressional Requesters

March 1994

NUCLEAR NONPROLIFERATION

Concerns With U.S. Delays in Accepting Foreign Research Reactors' Spent Fuel

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GAO

United States
General Accounting Office
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Resources, Community, and
Economic Development Division

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The Honorable Charles E. Schumer
House of Representatives

The Honorable John Glenn
Chairman, Committee on Governmental
Affairs
United States Senate

A key nonproliferation goal of the United States is to discourage the use of highly enriched uranium fuel (HEU), a material that can be used to make nuclear bombs, in civilian nuclear programs worldwide. Research reactors are of particular concern because the major civilian use of HEU is as fuel in these reactors. U.S. officials question the safety of spent (used) HEU fuel left in interim storage at reactor sites throughout the world and, for security reasons, would prefer that this spent fuel be consolidated and permanently stored in the United States.

The Reduced Enrichment for Research and Test Reactors Program was created to convert research reactors from HEU to low enriched uranium (LEU)—a material not directly usable in nuclear weapons. A primary motivation for research reactors to participate in the program was the willingness of the United States to take back their spent fuel. Since 1959, operators of foreign research reactors have been using HEU fuel that they leased or purchased from the United States for such things as medical research, materials testing, and the production of medical isotopes. Beginning in 1968, the Department of Energy (DOE) took back the spent HEU fuel, reprocessed it, and stored the resulting waste at the Savannah River Site, a DOE weapons production facility in South Carolina. Spent LEU fuel was taken back beginning in 1986. However, in 1988 and 1992, respectively, DOE allowed these practices, known as the Off-Site Fuels Policy, to expire. DOE determined that the fuels policy could not be renewed until the necessary environmental studies were completed. No spent HEU or LEU fuel of U.S. origin has been taken back since the fuels policy expired, despite warnings from operators of foreign research reactors that they were facing fuel storage problems.

This report provides you information on (1) the effects of delays in renewing the Off-Site Fuels Policy on U.S. nonproliferation goals and programs—specifically, the reduced enrichment program, (2) DOE's efforts

to renew the fuels policy, and (3) the price to be charged to the operators of foreign reactors for DOE's activities in taking back spent fuel.

Results in Brief

Delays in renewing the Off-Site Fuels Policy have made participation in the reduced enrichment program less desirable to those participants that have converted their reactors, at substantial expense, to LEU, a fuel that offers reduced reactor performance at higher cost. DOE officials acknowledge that failure to renew the fuels policy could lead these reactor operators to revert to HEU fuel—especially since it now may be available from Russia and other sources. Furthermore, because the United States did not take back their fuel, two foreign research reactors—one in Belgium and the other in Germany—had their spent HEU fuel reprocessed, an activity that is inconsistent with U.S. nonproliferation goals.

DOE officials plan to renew the fuels policy as soon as DOE can address the environmental impact of transporting the fuel and storing it in both existing and new storage units, possibly by June 1995. Under the policy, DOE proposes to accept up to about 15,000 fuel elements containing HEU or LEU of U.S. origin over a 15-year period. In the near term, DOE plans to accept spent fuel from foreign research reactors that it has identified as those that may be forced to reprocess their spent fuel or shut down their reactors because of fuel storage problems, as soon as an environmental assessment is approved. DOE proposes to store this spent fuel in existing storage space at DOE's Savannah River Site. The remaining spent fuel elements from the foreign reactors will not be accepted until a more complex environmental impact statement has been completed. Once all outstanding issues have been resolved, DOE officials plan to build new storage units at the existing DOE facilities and take back the remaining spent HEU and LEU fuels. The amount eligible for return under a renewed policy—approximately 75 metric tons—will be minimal compared to the approximately 96,000 metric tons of U.S. spent fuel that DOE estimates will have to be permanently disposed of by the year 2020.

If the fuels policy is renewed, DOE officials plan to charge the operators of foreign research reactors for accepting the spent fuel, storing it, preparing it for disposal, and disposing of it permanently in a U.S. repository. As of March 1994, DOE officials had not completed work on estimates of the prices necessary to recover DOE's costs, but a preliminary analysis estimated the cost at about $3,500 per kilogram of spent fuel. Operators of research reactors told us that they would look for alternative solutions,

such as reprocessing, if DOE's charges for returning spent fuel are so costly that research reactors cannot afford to pay them.

Background

Because research reactors are smaller than commercial power reactors, generally they have less space on-site for storing spent fuel. When storage pools are filled, the reactor operators must either close down the reactors or remove some of the spent fuel elements from temporary storage space. The options for dealing with the spent fuel include reprocessing it or storing it for an indefinite period at the reactor sites. As a result, some U.S. officials have encouraged the renewal of the Off-Site Fuels Policy. Under its proposed plan, DOE will take back 15,000 spent fuel elements from 130 research reactors in 42 countries—about 75 metric tons.

In attempting to renew the fuels policy, DOE published an environmental assessment in February 1991. The environmental assessment contained a proposed finding of "no significant impact," which would have enabled DOE to renew the policy and accept new shipments. The proposed finding of no significant impact was negatively received by environmental groups, and according to a DOE official, no follow-up action to revise the environmental assessment or to address the renewal of the policy was undertaken until April 1992. At that time, DOE issued a press release announcing its decision to phase out the reprocessing of spent fuel and began an internal review of the fuels policy.

In a recent meeting, DOE officials characterized their actions to take back the spent fuel as creating a new Foreign Research Reactor Spent Fuel Acceptance Policy instead of renewing the Off-Site Fuels Policy. For the purpose of clarity and consistency in this report, we will refer to DOE's actions as renewing the fuels policy, not establishing a new one.

Delays in Taking Back Spent Fuel Negatively Affect U.S. Nonproliferation Goals

Because DOE has not renewed the fuels policy, participation in the reduced enrichment program has become less desirable because a primary motivation for research reactors to participate in the program was the willingness of the United States to take back their spent fuel. As a result of the delay, two foreign research reactors have already reprocessed spent HEU fuel. Moreover, failure to renew the fuels policy may also affect the negotiations for the Treaty on the Nonproliferation of Nuclear Weapons, which expires in 1995.

Participation in the Reduced Enrichment Program May Be Affected by the Lapse of the Fuels Policy

DOE and State Department officials have said that further delays in renewing the fuels policy, leaving spent HEU fuel at research reactors abroad, can threaten the success of the reduced enrichment program and result in an increased use of HEU fuel—an outcome inconsistent with U.S. nonproliferation goals.

Through the reduced enrichment program, the United States has had success in encouraging the operators of foreign research reactors to convert to LEU fuel. According to an official at Argonne National Laboratory (a DOE contractor), 12 of the 41 operating research reactors have been fully converted. These 12 reactors use fuel of U.S. origin and have power of at least 1 megawatt. Three other reactors have been partially converted. Twelve of the remaining 26 research reactors are operating in steps that could lead to conversion, and more than half of the 12 are already planning to convert. Furthermore, some of the reactor operators not currently planning conversion provide other support to the reduced enrichment program. For example, the operators of a research reactor in the Netherlands contracted with Argonne National Laboratory to test LEU fuels for reactor conversion. (App. I summarizes the status of foreign research reactors that have and have not converted to LEU fuel.)

Despite the success of the reduced enrichment program, operators of research reactors and DOE officials warn that the program could be jeopardized by the lapse of DOE's fuels policy. A primary motivation for the reactor operators to participate in the reduced enrichment program was the willingness of the United States to take back their spent fuel. The operators of research reactors that have converted to LEU fuel have questioned why they should continue to participate in the reduced enrichment program, especially since HEU fuel is available within the European Atomic Energy Community (EURATOM)[1] and since Russia may offer a supply of HEU as well. According to these participants, fewer tests can be conducted with the reactors operating on LEU fuel, and conversion will result in higher fuel-cycle costs and, in some cases, in licensing problems. DOE acknowledges these limitations and told us that the reactor operators that have already converted might revert to HEU fuel and obtain fuel from another supplier.

In its February 1994 draft environmental assessment, which was developed to enable DOE to accept a limited number of spent fuel elements in the near term, DOE states that if the operators reprocess this fuel, they

[1]EURATOM is composed of 12 countries: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. These countries are treated as a single entity for the purposes of trade in and transfer of nuclear materials to the United States.

will likely continue to operate on, or revert to, HEU fuel. The only available reprocessing facility for research reactor fuel is AEA Technology, part of the United Kingdom's Department of Trade and Industry, located in Dounreay, Scotland; it will reprocess only HEU, not LEU, fuel elements. Furthermore, an AEA official told us that AEA Technology faces shutting down its reprocessing plant if new commitments from research reactors for reprocessing are not received by the spring of 1994. If the operators rely upon reprocessing for spent fuel management, they will have to maintain HEU fuel operations, contrary to U.S. nonproliferation goals.

DOE Does Not Require U.S. Research Reactors to Convert to LEU

Participation in the reduced enrichment program requires converting, at substantial expense, to LEU, a fuel that offers reduced performance at higher cost, and DOE has not required U.S. research reactors to convert. DOE officials acknowledge that this situation is unfair to the foreign operators that have converted their reactors under the reduced enrichment program.

DOE leases HEU fuel to 35 U.S. university research reactors. However, only five have been converted, and eight others have plans for conversion. The remaining 22 university reactors have enough HEU fuel to last the duration of their operating life; therefore, operators are not planning to convert them. Furthermore, DOE officials recently asked the operators of the eight university reactors planning to convert to postpone their conversion and maintain their fuel elements on-site so that all storage spaces available at the Savannah River Site can be used to alleviate the storage crises facing the foreign research reactors. However, DOE officials do expect these eight U.S. university reactors to convert to LEU fuel, once the environmental impact statement is approved for building additional dry storage. In the meantime, DOE has coordinated with Nuclear Regulatory Commission officials and representatives of the university reactors to ensure that the U.S. reactors will not encounter storage or licensing problems as a result of the postponement.

Despite U.S. pressure on the foreign research reactors to participate in the reduced enrichment program, the four DOE-operated research reactors also continue to use HEU fuel. In September 1993, the U.S. Assistant Secretary of State for Politico-Military Affairs wrote a letter to DOE requesting that it convert its research reactors to LEU fuel, acknowledging that conversion would require the development of a new high-density LEU fuel. The letter said that:

> Failure [to ensure that LEU is used in our domestic programs] would send a powerful, negative signal to governments in Western Europe, Canada, Australia and Japan which have been cooperating with us in the effort to reduce the use of HEU worldwide. The message would not be lost on the Russian Government, which could be expected to ignore any U.S. pleas not to step in and start selling HEU for research reactors and medical isotopes to customers around the world.

Two Foreign Research Reactors Reprocess HEU Fuel Because of DOE's Inaction

In a September 1993 letter, the Director General of the Belgian BR2 reactor notified DOE officials that BR2 was experiencing an emergency situation. According to the Director General, licensing authorities had determined that the reactor's storage pool was overloaded and that the reactor would have to be shut down if 144 spent fuel elements were not removed from the storage pool by the end of the year so that repairs could be made to the storage area. To ensure the removal of these 144 elements, reactor officials entered into negotiations with AEA Technology to reprocess the fuel; shipments of spent fuel from Mol, Belgium, to Dounreay, Scotland, were scheduled to take place during the last quarter of 1993. In the letter, the Director General also told DOE officials that if a firm guarantee to take back the fuel could be made by October 1, 1993, BR2 officials would be willing to reconsider their decision to reprocess.

DOE officials did not reply to the BR2 representatives' letter; consequently, BR2 officials signed a contract with AEA Technology to reprocess 144 fuel elements. On October 26, 1993, following consultations with the Council on Environmental Quality and other interested agencies, in order to prevent the reprocessing of BR2's spent fuel, the Secretary of Energy approved the implementation of emergency provisions to allow DOE to accept the first 144 spent fuel elements, before completing its environmental assessment. In a letter to BR2 officials, DOE officials agreed to pay up to $600,000 to terminate BR2's contract with AEA and established a price for the spent fuel that was less than DOE's full cost of taking it back. However, BR2 officials did not withdraw from their contract obligations to reprocess fuel at AEA Technology.

In a similar case, a German reactor shipped 132 fuel elements for reprocessing at AEA Technology during September and October 1993. The operator noted that he no longer felt he could rely on the renewal of the fuels policy. Furthermore, according to DOE officials, German law stipulates that reactors may not operate without a firm plan for storage and disposal of spent nuclear fuel. (For additional information, see app. II.)

EURATOM Agreement Permits Reprocessing of Fuels of U.S. Origin

An Agreement for Cooperation Between the United States of America and the European Atomic Energy Community Concerning Peaceful Uses of Atomic Energy permits members to reprocess spent fuel within the Community without consent from the United States. This agreement will expire in December 1995, and negotiations are currently under way to develop a new agreement. (For additional information about the U.S.-EURATOM agreement, see app. III.)

Failure to Renew Policy May Negatively Affect Treaty Negotiations

The lapse of DOE's fuels policy may also affect the 1995 Nuclear Nonproliferation Treaty conference. Since it took effect in 1970, the Treaty on the Nonproliferation of Nuclear Weapons has been the principal tool used by the international community to prevent the spread of nuclear weapons.[2] If research reactors operators are forced to shut down their reactors or seek reprocessing, DOE officials believe that these affected countries are likely to accuse the United States of not having fulfilled its treaty obligations.

DOE Plans to Take Back Spent Fuel of U.S. Origin

DOE officials plan to renew the fuels policy as soon as an environmental impact statement can be completed and approved, possibly in June 1995. However, in the near term, DOE plans to accept spent fuel from those reactors for which the expiration of DOE's acceptance of spent fuel may threaten participation in the reduced enrichment program. This threat could occur, for example, if the failure to take back the fuel would discourage the reactors' participation in the program. If fuel is accepted in the near term, it will be accommodated in existing storage facilities at Savannah River and will require an environmental assessment limited to addressing the impact of the fuel's transport to and storage in these facilities. Final approval of the draft environmental assessment is planned for March 1994, and DOE officials hope to begin receiving this fuel later this year. The more comprehensive environmental impact statement needed to renew the fuels policy will assess the impacts of building additional storage units at Savannah River as well as the impacts of transporting the fuel to and storing it at Hanford, Washington; the Idaho National Engineering Laboratory; and other locations. According to DOE officials,

[2]Under the treaty, nuclear weapons states pledged to facilitate the transfer of peaceful nuclear technology to nonnuclear weapons states but not to assist them in acquiring nuclear weapons. Because the treaty expires in 1995, the conference will determine whether the treaty should continue indefinitely or be extended for an additional fixed period. The United States strongly supports indefinite extension of the treaty, and according to U.S. officials, the key to its success is likely to be the ability of the United States to convince other parties to the treaty that the United States has fulfilled its obligations to share with nonnuclear weapons countries the benefits of peaceful nuclear cooperation.

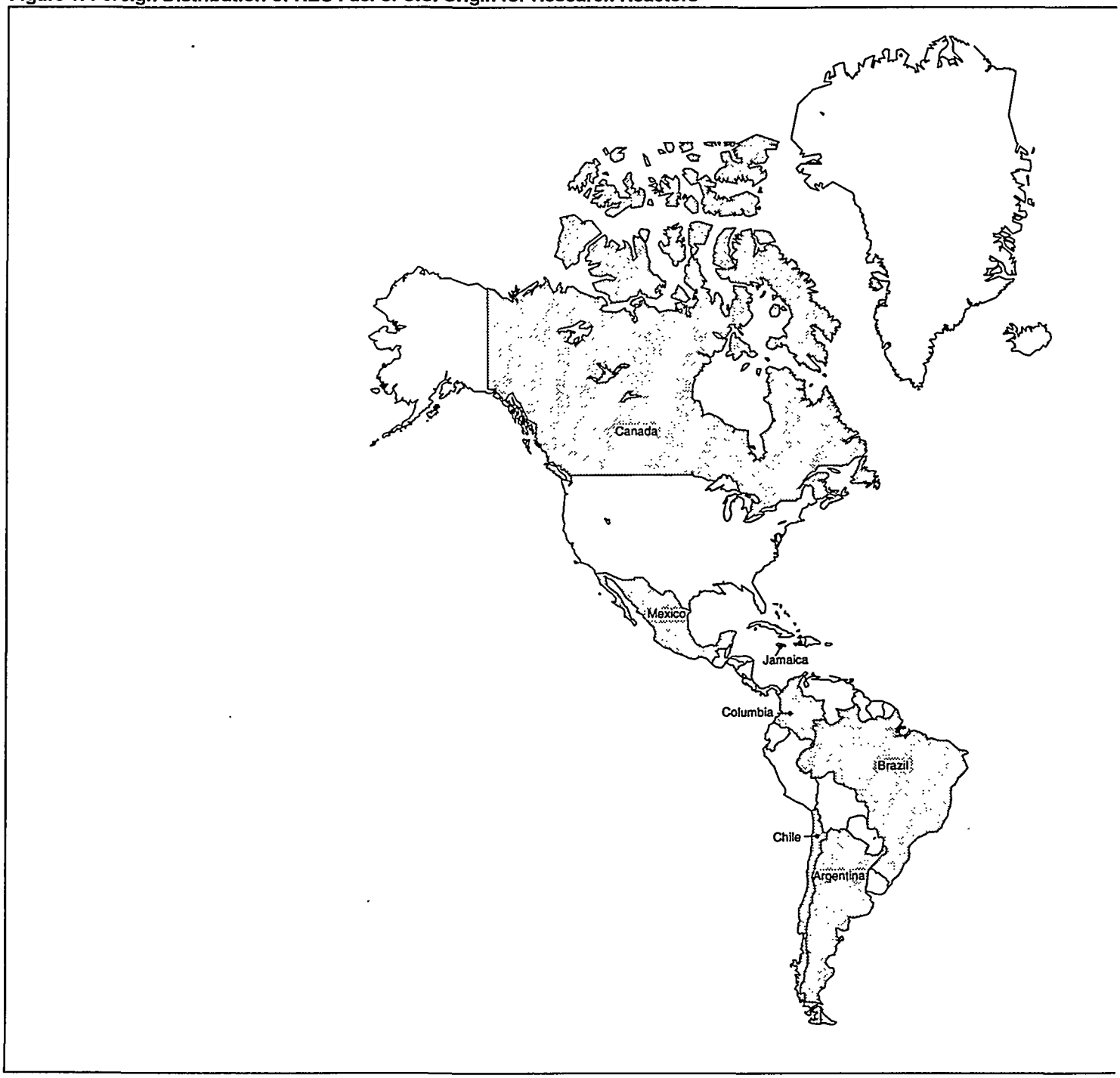
the remaining spent HEU fuel and some spent LEU fuel cannot be taken back before the completion of an environmental impact statement.

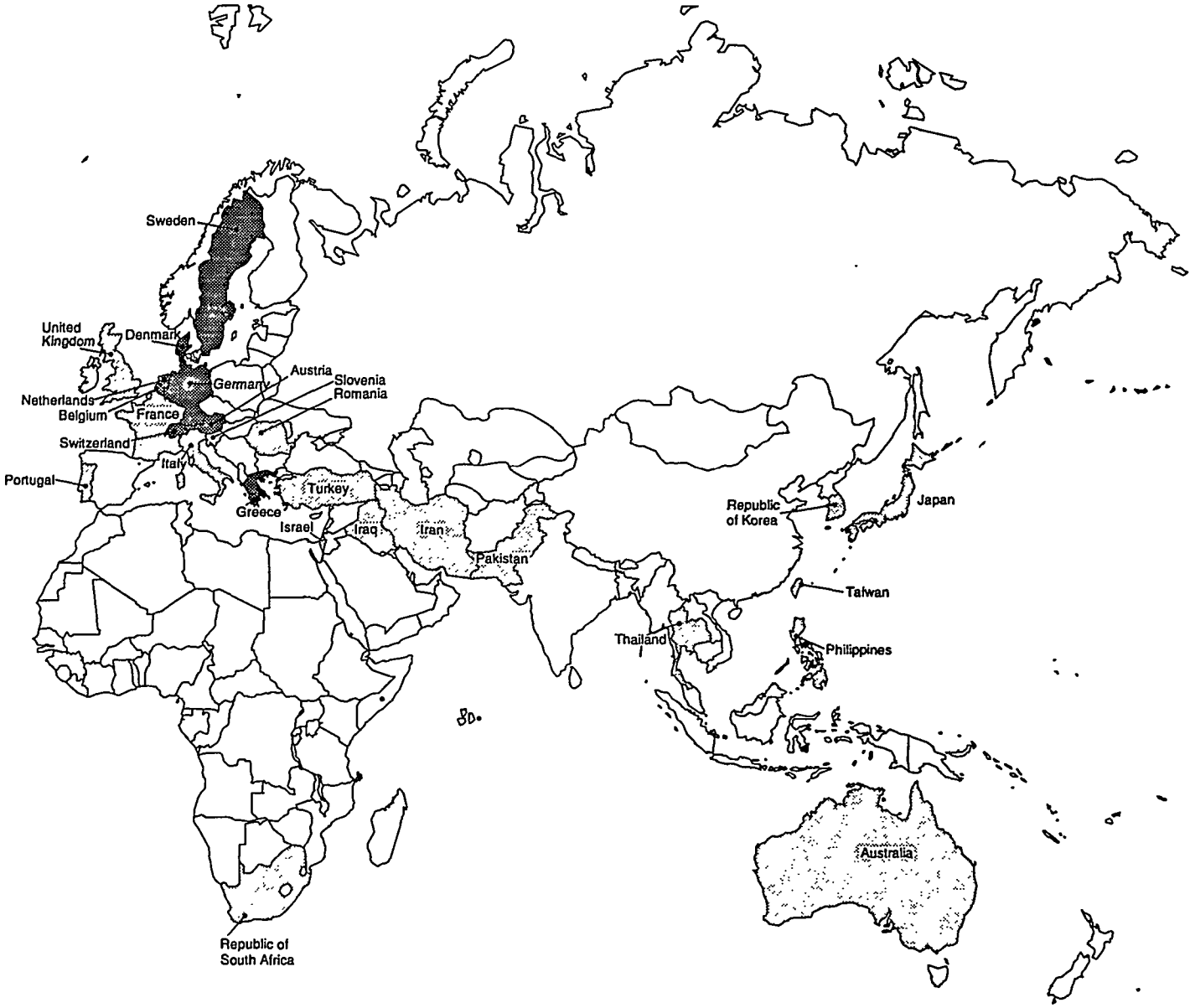
Although DOE officials had previously surveyed the foreign research reactors to determine their near-term spent fuel storage needs, a U.S. delegation visited the 11 research reactors in Europe and Australia in January 1994. These site visits, conducted by representatives from DOE and the State Department, provided them with first-hand observations of the reactors' spent fuel storage situation. In addition, the U.S. delegation discussed all feasible alternatives to returning spent fuel to the United States before December 1995.

As a result of these site visits, DOE officials have determined that 359 spent fuel elements from nine European reactors need to be returned to the United States in the near term to ensure that the reactor operators that have the option to reprocess are not forced to exercise that option—a position consistent with U.S. nonproliferation policy. This figure of 359 spent fuel elements is significantly less than the amount obtained in the earlier survey, in which the 11 reactor operators requested that DOE accept 970 spent fuel elements. The transport of 359 spent fuel elements would require a total of 16 casks. The capacity of those same 16 casks is 448 spent fuel elements. Accordingly, DOE proposes to allow each reactor to transport full rather than partially full casks. Therefore, in fact, DOE plans to accept 448 fuel elements in order to utilize the full capacity of those casks.

Figure 1 shows the 33 countries that have research reactors eligible to send back spent HEU fuel elements under a renewed fuels policy and highlights the 8 countries with reactors that DOE has determined will face storage crises by January 1996. (See app. IV for additional information on the crisis situations at these reactors.) The majority of spent HEU fuel elements of U.S. origin are in the EURATOM countries, Japan, and Canada.

Figure 1: Foreign Distribution of HEU Fuel of U.S. Origin for Research Reactors




Sweden
United Kingdom
Denmark
Netherlands
Belgium
France
Germany
Austria
Slovenia
Romania
Switzerland
Italy
Portugal
Greece
Turkey
Israel
Iraq
Iran
Pakistan
Republic of Korea
Japan
Taiwan
Thailand
Philippines
Australia
Republic of South Africa
Countries with research reactors that DOE has determined will face potential storage crises prior to 1/96 if the Policy is not renewed.
Both colors-Countries with research reactors eligible to return U.S.-origin HEU fuel if the Policy is renewed.

If the environmental impact statement is successfully completed and all outstanding issues are addressed, DOE can then renew the fuels policy and accept all of the remaining spent HEU fuel from the foreign research and test reactors as well as the LEU fuel from the participants in the reduced enrichment program. Reactor operators would then be permitted by DOE to return LEU fuel for 10 years following their first order of LEU fuel for conversion. However, DOE would require the reactor operators to place LEU orders within 5 years of the renewal of the fuels policy in order to qualify for this return. According to DOE officials, the existing storage space at Savannah River can accommodate about 2,350 of the approximately 15,000 fuel elements that may be eligible for return. DOE officials plan to store the remaining waste in dry storage facilities.

DOE officials expect that the environmental impact statement required to reinstate the fuels policy will be issued in June 1995, but this date assumes that the supporting studies will reveal no significant environmental impacts requiring a change in DOE's transport or storage plans. The return of some of the spent fuel will also depend on the readiness of dry storage. One expert told us that, realistically, construction of new storage facilities will take 2 years or more to complete. DOE officials told us that storage conditions for some of the reactors needing to ship fuel in early 1996 might be strained because of this time frame. However, these officials are considering options to provide an additional 1,000 spaces in existing storage in the event that the dry storage facilities are not ready by that time.

If the fuels policy is renewed, the amount of spent fuel eligible for return would be minimal compared to the quantity of spent fuel already stored in the United States. DOE has estimated that the amount of nuclear waste for permanent disposal will total around 96,000 metric tons by the year 2020. This figure includes waste generated at commercial U.S. nuclear power plants as well as waste produced at DOE's nuclear facilities. In comparison, under the proposed plan, DOE will take back 15,000 spent fuel elements from 130 research reactors in 42 countries—about 75 metric tons.[3] The 75-metric-ton figure includes about 2 metric tons that will be eligible for return in the near term under an approved environmental assessment for storage at the Savannah River Site and about 73 metric tons that will be eligible when the more complex environmental impact statement is satisfactorily completed.

[3]These figures are useful for comparison only. DOE officials caution that spent fuel elements vary in size and weight; the average spent fuel element weighs about 5 kilograms. We have estimated that 15,000 fuel elements equal about 75 metric tons.

Price Charged to Return Fuel Will Influence Reactor Operators' Choice of Options

If the fuels policy is renewed, DOE officials plan to charge the operators of foreign research reactors for accepting the spent fuel, storing it, preparing it for disposal, and disposing of it permanently in a U.S. repository. DOE officials told us that although they are considering a price that would cover DOE's full costs of taking back the spent fuel, no final decision on price has been made. One exception to full cost recovery is DOE's price to developing countries; they will be reimbursed for the costs of shipping their spent fuel and will not be charged for storage and permanent disposal. As of March 1994, DOE officials had not completed work on estimates of full cost recovery, but a preliminary analysis estimates the present value of the cost at about $3,500 per kilogram.

These DOE figures differ substantially from charges levied before the Off-Site Fuels Policy lapsed. In the past, DOE officials charged reactor operators $1,000 per kilogram to accept the spent fuel and, in addition, gave the operators credits toward purchasing fresh HEU fuel. DOE officials note that the policy offered the reactor operators a lower cost and simpler solution for managing the research reactors' spent fuel than was otherwise available, and it was seen by the operators as an essential quid pro quo for incurring the substantial technical and financial expenses of converting to LEU fuel. However, at that time the United States had an active reprocessing program as a part of its weapons complex, and the costs for reprocessing incremental amounts of spent fuel from research reactors were minimal.

If DOE's charges for taking back the spent fuel are so costly that the research reactors cannot afford to pay them, the operators told us that they would look for alternative solutions. Yet few options are currently available to the operators of foreign research reactors. For instance, while one option is reprocessing at AEA Technology, in some countries reprocessing research reactor fuel is against national policies or politically unpopular, and reactor operators are prohibited from shipping fuel elements for reprocessing. Several reactor operators are considering the option to construct dry storage facilities, and at least one has already begun storing spent HEU fuel in this way. However, the political unpopularity of any nuclear installation in some countries makes reactor operators reluctant to apply for a license to expand their existing storage facilities, for fear of the negative publicity that could result in shutting down a reactor.

Conclusions

By renewing the Off-Site Fuels Policy, DOE officials can encourage the continued success of the reduced enrichment program by (1) offering the reactor operators an alternative to either reprocessing the spent fuel or storing it for the long term at the reactor sites and (2) providing them with additional time to develop their own plans for future permanent disposal. In the near term, accepting a minimal number of spent fuel elements will enable nine foreign research reactors to continue operating without reprocessing spent fuel of U.S. origin.

The acceptance of the fuel in the near term and the ultimate renewal of the fuels policy suggest that U.S. officials are concerned with maintaining consistency in U.S. nonproliferation policy. As a result, in the forthcoming Nuclear Nonproliferation Treaty conference and other future negotiations with the affected countries, especially EURATOM members, the United States may be in a stronger position by demonstrating this consistency.

The price of accepting spent fuel from the operators of foreign research reactors will partly determine the success of the fuels policy. DOE officials have not yet decided if they will try to recover full costs from the charges levied on reactor operators to accept spent fuel or if they will accept a partial recovery in order to take back as much spent fuel as possible. However, if renewing the fuels policy is intended to support the U.S. nonproliferation goals, the price should be affordable to the reactor operators and not encourage them to turn to other solutions that may be inconsistent with the U.S. nonproliferation policy.

Recommendations to the Secretary of Energy

To ensure that operators of foreign research reactors are not forced to reprocess spent fuel of U.S. origin or shut down reactors as a result of the lapse of the Off-Site Fuels Policy, we recommend that the Secretary of Energy accept the minimum amount of spent fuel from the foreign research reactors that DOE has determined will constitute storage crises in the near term.

To minimize the civilian use and commerce of highly enriched uranium, we recommend that the Secretary of Energy take immediate action to complete all environmental requirements to renew the Off-Site Fuels Policy and begin accepting the spent fuel within a time period that circumvents future crisis situations.

To secure the return of the maximum amount of spent highly enriched uranium fuel, we recommend that the Secretary assess the operators of

foreign research reactors a charge for returned spent fuel that balances the need to minimize the cost burden on the United States with the reactor operators' need for a reasonable, affordable charge.

Agency Comments

We discussed the facts presented in this report with the State Department's Director, Nuclear Energy Affairs, Bureau of Politico-Military Affairs; the Acting Director, Office of Nuclear Export Controls, Bureau of Politico-Military Affairs; DOE's Acting Director, Program Management Division, Spent Fuels Management and Special Projects; and the Director, Project Activities, Environmental Safety and Health Division. In general, these officials agreed with the facts presented and gave us additional clarifying information. We revised the text, as appropriate. However, as requested, we did not obtain written agency comments on a draft of this report.

Scope and Methodology

To address our objectives, we interviewed officials and reviewed documentation from DOE and the Departments of State and Transportation, the Nuclear Regulatory Commission, the U.S. Coast Guard, the Council on Environmental Quality, and Sandia National Laboratory. We met with EURATOM Safeguards and Supply Agency officials in Luxembourg City, Luxembourg, and Brussels, Belgium, to obtain their views on the lapse of the Off-Site Fuels Policy and its effect on the negotiations for the U.S.-EURATOM agreement.

To better understand the effects of the fuels policy lapse on research reactors, at a meeting in Washington, D.C., we interviewed representatives from seven foreign research reactors directly affected by the status of the fuels policy and discussed their various waste management options. We also met with officials of the Petten Research Reactor and the Mol BR2 Research Reactor in Petten, the Netherlands, and Brussels, Belgium, respectively. In addition, we interviewed representatives of the AEA Technology reprocessing plant in Dounreay, Scotland, to discuss reprocessing options for research reactor operators.

We performed our review between August 1993 and February 1994, in accordance with generally accepted government auditing standards.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the

date of this letter. At that time, we will send copies of the report to appropriate congressional committees; the Secretaries of Defense, Energy, and State; and the Chairman, Nuclear Regulatory Commission. We will make copies available to others upon request.

This report was prepared under the direction of Victor S. Rezendes, Director, Energy and Science Issues, who may be reached at (202) 512-3841. Other major contributors to this report are listed in appendix V.

Keith O. Fultz
Assistant Comptroller General

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Abbreviations

DOE	Department of Energy
EURATOM	European Atomic Energy Community
GAO	General Accounting Office
HEU	highly enriched uranium
LEU	low enriched uranium
NNPA	Nuclear Nonproliferation Act of 1978
UK	United Kingdom

Status of Foreign Research and Test Reactors' Conversion to LEU Fuel, as of January 1994

Table I.1: Conversion Status of Reactors With Power Equal to or Greater Than 1 Megawatt

Reactor	Country	Power in megawatts	Kilograms of uranium-235 per year	Begin LEU conversion	End LEU conversion	Comment
Reactors fully converted						
RA-3	Argentina	2.8	2.0	1990	1990	Fully converted
ASTRA	Austria	8.0	1.8	1983	1990	Fully converted
NRU	Canada	125.0	65.2	1992	1993	Fully converted
DR-3	Denmark	10.0	7.5	1988	1990	Fully converted
OSIRIS	France	70.0	44.3	1979	1979	Fully converted
FRG-1	Germany	5.0	2.3	1991	1991	Fully converted
NRCRR	Iran	5.0	0.0	1991	1991	Fully converted
JMTR	Japan	50.0	34.5	1993	1994	Fully converted
PARR	Pakistan	5.0	0.6	1991	1991	Fully converted[a]
PRR-1	Philippines	1.0	0.4	1987	1987	Fully converted
R2	Sweden	50.0	27.0	1990	1993	Fully converted
THOR	Taiwan	1.0	0.0	1978	1987	Fully converted
Total		**332.8**	**185.6**			
Reactors partially converted						
IEA-R1	Brazil	2.0	1.0	1981	1995 or later	Partially converted
TRIGA	Romania	14.0	11.0	1992	1995 or later	Partially converted
SAPHIR	Switzerland	10.0	5.6	1986	1996	About 50 percent converted
Total		**26.0**	**17.6**			
Reactors that have ordered LEU fuel elements for conversion						
GRR-1	Greece	5.0	2.7	1994	1997 or later	LEU fuel ordered
HOR	Netherlands	2.0	1.7	1994	1997 or later	LEU fuel ordered
TR-2	Turkey	5.0	1.5	1994	1997 or later	LEU fuel ordered
Total		**12.0**	**5.9**			
Reactors now irradiating or which have irradiated LEU prototypes						
MNR	Canada	5.0	1.91	1995 or later	1995 or later	Conversion feasible
SILOE	France	35.0	22.5	1995 or later	1995 or later	Conversion planned
FRJ-2	Germany	23.0	17.9	1995 or later	1995 or later	Conversion planned
KUR	Japan	5.0	2.1	1998 or later	1998 or later	Conversion planned
JRR-4	Japan	3.5	0.9	1996	1996	Conversion planned
HFR Petten	Netherlands	45.0	35.6			Conversion feasible
Total		**116.5**	**80.9**			
Reactors planning conversion						
Lo Aguirre	Chile	10.0	0.0	1995 or later	1995 or later	Conversion planned. All HEU is of French origin[a]

(continued)

Reactor	Country	Power in megawatts	Kilograms of uranium-235 per year	Begin LEU conversion	End LEU conversion	Comment
La Reina	Chile	5.0	1.0	1995 or later	1995 or later	Conversion planned. Half of HEU used originated in the United Kingdom[a]
BER-2	Germany	10.0	4.8			Conversion planned
Total		**25.0**	**5.8**			
Reactors that can be converted						
HIFAR	Australia	10.0	7.5			Conversion feasible. Half of HEU fuel supplied by United Kingdom
FMRB	Germany	1.0	1.0			Conversion feasible
FRM	Germany	4.0	2.6			Conversion feasible
IRR-1	Israel	5.0	0.0			Conversion feasible[a]
TRIGA	Korea	2.0	1.0			Conversion feasible
TRIGA	Mexico	1.0	0.7			Conversion feasible
RPI	Portugal	1.0	0.9			HEU core on hand since 1974
SAFARI	S. Africa	20.0	11.7			Uses own 60 percent enriched uranium, with the exception of 1 percent HEU of U.S. origin
Total		**44.0**	**25.4**			
Reactors that cannot be converted with current technology						
BR-2	Belgium	80.0	27.0			Suitable LEU fuel not available
RHF	France	57.0	51.0			Suitable LEU fuel not available
ORPHEE	France	14.0	14.7			Suitable LEU fuel not available
Total		**151.0**	**92.7**			
Lifetime cores						
Scarabee	France	20.0	0.0			Lifetime core
R2-0	Sweden	1.0	0.0			Lifetime core
Total		**21.0**	**0.0**			
Reactors to be shut down						
JRR-2	Japan	10.0	9.9			To be shut down in 1995
Total		**10.0**	**9.9**			
Reactors shut down						
NRX	Canada	24.0	1.0			Shut down in 1993
FRG-2	Germany	15.0	10.7			Shut down in 1993
HERALD	UK	5.0	3.0			Shut down in 1990

(continued)

Reactor	Country	Power in megawatts	Kilograms of uranium-235 per year	Begin LEU conversion	End LEU conversion	Comment
DIDO	UK	25.5	11.3			Shut down in 1990
PLUTO	UK	25.5	11.3			Shut down in 1990
Total		**95.0**	**37.3**			

[a]The country in which this reactor is located is not a party to the Treaty on the Non-Proliferation of Nuclear Weapons.

Source: GAO's analysis of data provided by Argonne National Laboratories.

Table I.2: Conversion Status of Reactors With Power of Less Than 1 Megawatt

Reactor	Country	Power in megawatts	Kilograms of uranium-235 per year[a]
Reactors fully converted[b]			
Reactors partially converted			
TRIGA	Austria	0.25	~0.0
TRIGA	Slovenia	0.25	~0.0
Reactors that have ordered LEU fuel elements for conversion[b]			
Reactors now irradiating LEU prototype elements[b]			
Reactors planning conversion			
IAN-R1	Columbia	0.03	~0.0
Reactors that can be converted			
RA-6	Argentina	0.5	~0.0
MOATA	Australia	0.1	~0.0
SAR-GRAZ	Austria	0.01	~0.0
Slowpoke Toronto	Canada	0.02	~0.0
Slowpoke Montreal	Canada	0.02	~0.0
Slowpoke Halifax	Canada	0.02	~0.0
Slowpoke Alberta	Canada	0.02	~0.0
Slowpoke Saskatchewan	Canada	0.02	~0.0
Ulyssee-Saclay	France	0.1	~0.0
Ulyssee-Strasbourg	France	0.1	~0.0
EOLE	France	0.01	~0.0
Silotte	France	0.1	~0.0
Apsara	India	0.4	~0.0
RB-3	Italy	10.4	~0.0
Slowpoke	Jamaica	0.02	~0.0
KUCA	Japan	10.4	~0.0
JMTRC	Japan	10.5	~0.0

(continued)

Reactor	Country	Power in megawatts	Kilograms of uranium-235 per year[a]
UTR-10 Kinki	Japan	10.7	~0.0
LFR	Netherlands	0.03	~0.0
AGN-211 P	Switzerland	0.002	~0.0
ZPRL	Taiwan	0.01	~0.0
SRRC-UTR	United Kingdom	0.3	~0.0
Consort	United Kingdom	0.1	~0.0
URR	United Kingdom	0.1	~0.0
Nestor	United Kingdom	0.03	~0.0
Jason	United Kingdom	0.01	~0.0
Neptune	United Kingdom	0.0	~0.0
Vulcan	United Kingdom	0.0	~0.0
Reactors that cannot be converted with current technology[b]			
Reactors to be shut down[b]			
Reactors shut down			
BR-02	Belgium	0.0005	~0.0
PTR	Canada	0.01	~0.0
Slowpoke Ottawa	Canada	0.02	~0.0
Slowpoke AECL (Kanata)	Canada	0.02	~0.0
Tammuz-2	Iraq	0.5	~0.0
SMR	Germany	0.0005	~0.0

[a]Numbers expressed in the last column indicate that the average amount of uranium-235 burned each year in these reactors is positive, but rounds to zero.

[b]No reactors currently meet this criterion.

Source: GAO's analysis of data provided by Argonne National Laboratories.

Late Action by DOE Fails to Prevent Belgium's BR2 Reactor From Reprocessing HEU Fuel

In an October 1992 letter, representatives of the Belgian BR2 reactor notified then-Secretary of Energy Watkins that they believed that DOE might be reneging on some of its obligations to them if it did not renew the Off-Site Fuels Policy. In addition, they noted that they were considering reprocessing their spent fuel, if DOE did not reaffirm its commitment to renew the policy and take action to do so.

In a September 1993 letter, the Director General of the BR2 reactor notified DOE officials that BR2 was experiencing an emergency situation. Licensing authorities had determined that the reactor storage pool was overloaded and that the reactor would have to be shut down if 144 spent fuel elements were not removed from the storage pool by the end of the year so that repairs could be made to the storage area. In order to ensure the removal of these 144 elements, reactor officials entered into negotiations with AEA Technology, part of the United Kingdom's Department of Trade and Industry, to reprocess the fuel; shipments of spent fuel from Mol, Belgium, to Dounreay, Scotland, were scheduled to take place during the last quarter of 1993. In the letter, the Director General also told DOE officials that if a firm guarantee to take back the fuel could be made by October 1, 1993, BR2 officials would be willing to reconsider their decision to reprocess.

DOE officials did not reply to the BR2 representatives' letter; consequently, BR2 officials signed a contract with AEA Technology to reprocess 144 fuel elements. DOE officials told us they did not respond to the letter because they were heavily committed to the production of the draft environmental assessment when the letter was received. According to these officials, in order to accept a first shipment of 144 spent fuel elements in 1993, DOE had to either complete the environmental assessment in 1993 or invoke the emergency provisions of the Council on Environmental Quality. In invoking these provisions, DOE had to identify to the Council an alternative means of fulfilling the requirements of an environmental review. Subsequently, on October 26, 1993, following consultations with the Council and other interested agencies, in order to prevent the reprocessing of BR2's spent fuel, the Secretary of Energy approved the implementation of the emergency provisions to allow DOE to accept the first 144 spent fuel elements immediately.

DOE officials agreed to pay up to $600,000 of BR2's contract termination fees and established a price that was less than DOE's full cost of taking back the spent fuel. The lower price made the return of the spent fuel affordable for the reactor officials. According to DOE officials, the BR2

officials rejected the offer because of political pressure from British authorities to fulfill the obligations of the reprocessing contract. However, in a November 1993 letter to DOE officials, BR2's Director General explained that because of upcoming inspection and maintenance activities imposed by the Belgian safety authorities and because of the continued operation of the BR2 reactor, the spent fuel storage situation may again become critical during the next 18 months. He noted that at times one-third to one-half of BR2's storage capacity will be lost because of the successive unavailability of individual storage pool compartments that are being inspected and repaired. Finally, he stated that:

> Politically, it is crucial and of utmost importance that a shipment of BR2 fuel to the United States effectively takes place in 1994. If not, the credibility of the US DOE and our faith in US DOE's capability to effectively implement its policies might completely be lost, and the return of spent fuel of the BR2 [reactor] to the United States might no longer be considered a viable option by [BR2's] Board of Directors and by Belgian Authorities.

In its February 1994 draft environmental assessment, DOE proposed the acceptance of 48 spent fuel elements from BR2 officials to deter the reprocessing of these elements. BR2 officials had requested that DOE accept 150 spent fuel elements.

German Reactor Operator Had Previously Reprocessed Spent HEU Fuel

In a similar case, a German reactor shipped 132 fuel elements for reprocessing at AEA Technology during October 1993. The operator noted that he no longer felt he could rely on the renewal of the fuels policy. Furthermore, German law stipulates that reactors may not operate without a firm plan for the storage and disposal of spent nuclear fuel. In the past, operators of German reactors had convinced the German licensing authorities that, on the basis of DOE's past practices, the United States was committed to taking back spent HEU fuel. As the years passed and the fuels policy was not renewed, according to the operators, they were forced to consider alternatives for dealing with their spent fuel.

In October 1993, the operator of the German reactor offered to DOE for purchase 16 kilograms of HEU that will result from the reprocessing of spent HEU fuel at AEA Technology. Initially, DOE officials responded that because of budget constraints, DOE was not interested. However, DOE officials are now reconsidering the purchase.

Status of the Agreement for Cooperation Between the United States of America and the European Atomic Energy Community Concerning Peaceful Uses of Atomic Energy

Every year since 1980, the President of the United States has issued an executive order implementing for successive 1-year periods a provision of the Nuclear Nonproliferation Act of 1978 (NNPA) that authorizes the continuation of peaceful nuclear cooperation with EURATOM in the interests of nonproliferation and of the common defense and security. These annual executive orders waive the effect of a statutory provision that would otherwise prohibit such exports on the ground that the U.S.-EURATOM Agreement for Peaceful Nuclear Cooperation does not afford the United States a consent right over reprocessing nuclear material of U.S. origin within the EURATOM community.

The NNPA, which amended the Atomic Energy Act of 1954, strengthens U.S. controls on the nonproliferation of nuclear weapons and materials by establishing new procedures and criteria for nuclear exports. The NNPA amendments required compliance with new criteria governing nuclear exports, including reprocessing restrictions, as a condition of license approval by the Nuclear Regulatory Commission. The NNPA amendments addressed the conflict between the new prior consent requirement for reprocessing and the absence of such a consent right in the existing EURATOM agreement, by providing that cooperation under the agreement would continue for 2 years without compliance with the new criteria, so that the agreement could be renegotiated and made consistent with new agreements that would be negotiated under the NNPA.

Continued cooperation with EURATOM after this 2-year period required an annual executive order waiving the prior consent provision, after a presidential determination that failure to cooperate would seriously prejudice the achievement of nonproliferation objectives or otherwise jeopardize the common defense and security.

Although the NNPA authorizes the issuance of waivers indefinitely, the legislative history of the amendments reveals that the committees reporting the bills containing the waiver provision were concerned whether such indefinite waivers were prudent. In their joint report, the Senate Committees on Governmental Affairs, Energy and Natural Resources, and Foreign Relations stated:

> . . . it must be noted that the committees deem 24 months to be a realistic amount of time to reach agreement. Hence, while there is provision for extensions, we hope that they will not become necessary.

The House Committee on International Relations similarly stated in its report:

> Any undue prolongation of the exemption would set an unfortunate precedent and undermine the central aim of the bill, which is to assure that rational criteria are evenly and consistently applied.

Despite these cautionary words, however, the United States has no right under the EURATOM agreement to demand renegotiation, and the original terms are still in effect. The EURATOM agreement is currently scheduled to expire in 1995, and negotiation talks on a new agreement meeting all the requirements of U.S. law are now occurring.

According to a State Department official, if a new agreement is not concluded prior to the expiration date, significant nuclear commerce between the two parties must be suspended. In addition, other agreements, such as the U.S.-Japan agreement, which depend upon the existence of a U.S.-EURATOM agreement for implementation of some of their provisions, may also be affected. The State Department official did not speculate on the prospects for concluding an agreement.

Selected Acceptance Scenarios for Spent HEU Fuel of U.S. Origin Prior to Completion of Environmental Impact Statement

Name and location of facility	Number of spent fuel elements that reactors asked DOE to accept prior to 1/96[a]	Minimum amount of fuel elements DOE has determined it must accept prior to 1/96 to avert reprocessing or reactor shutdown	DOE's proposed acceptance, based on full casks[b]
BR2/Belgium	150	48	72
HOR/Netherlands	33	20	33
HFR/Netherlands	66	24	33
DR-3/Denmark	72	12	36
R-2/Sweden	64	58	64
BER-2/Germany	105	52	52
FRG-1/Germany	132	0	0
SAPHIR/Switzerland	100	53[c]	66
ASTRA/Austria	26	26	26
GRR-1/Greece	108	66[d]	66
HIFAR/Australia	114	0	0
Total	**970**	**359**	**448**

[a]These reactors indicated that they would face crisis situations, such as forced shut down or reprocessing, if DOE did not take back at least this amount of spent fuel by December 1995.

[b]According to DOE officials, the cost of shipping nuclear materials is calculated by weight. Because the shipping container weighs much more than the fuel rods inside, it is economical to fill each container to capacity.

[c]According to DOE, shipment of 33 spent fuel elements provides for continued operations, but 53 resolves a safety concern.

[d]According to DOE, shipment of 40 spent fuel elements provides for continued operations, but 66 resolves a safety concern.

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