REPORT BY THE

Comptroller General

OF THE UNITED STATES

Status And Commercial Potential Of The Barnwell Nuclear Fuel Plant

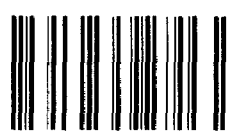
In October 1981, President Reagan lifted the indefinite deferral on commercial reprocessing of nuclear spent fuel in the United States that the previous administration had established in 1977. This raised speculation that the Barnwell Nuclear Fuel Plant--a privately owned, partially constructed reprocessing plant--could become operational This report examines the status and the commercial potential of the plant.

Three overall observations can be drawn from the information presented in the report.

--The potential for commercial reprocessing to develop in the United States is driven by economics in the private marketplace which is closely tied to the future role that nuclear power will have as a domestic energy source.

--Before private industry seriously considers starting another commercial reprocessing venture, nuclear industry representatives believe three issues associated with commercial reprocessing--the use of plutonium as a fuel source, an acceptable solidified high-level radioactive waste form, and guarantees against changes in federal policies--must be addressed

--Technical assessments of the plant and GAO discussions with knowledgeable persons within and outside the government disclose no apparent fundamental problems that currently would prohibit the plant from operating when completed. A number of technical concerns and licensing issues need to be resolved, however, before the plant could operate as a commercial venture. In addition, the economic prospect for the plant as a commercial venture is not promising.



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WASHINGTON D.C. 20548

B-211600

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

Dear Mr. Chairman:

This report responds to your request dated April 9, 1982. It examines the status of the Barnwell Nuclear Fuel Plant and its potential for becoming operational as a commercial venture.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of the report. At that time, we will send copies to the Secretary of Energy, the Nuclear Regulatory Commission, and interested Committees and Members of Congress. Copies will also be made available to others upon request.

Sincerely yours,

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT
TO THE CHAIRMAN, SUBCOMMITTEE ON
ENERGY CONSERVATION AND POWER,
COMMITTEE ON ENERGY AND COMMERCE
HOUSE OF REPRESENTATIVES

STATUS AND COMMERCIAL POTENTIAL OF THE BARNWELL NUCLEAR FUEL PLANT

D I G E S T

From the beginning of the nation's nuclear power program, the government and the nuclear industry assumed that commercial reprocessing--the recovery, as a private business venture, of uranium and plutonium from spent (used) nuclear reactor fuel for reuse as fuel--would be an integral step in making nuclear power a major long-term source of electricity. Initially, recovered uranium and plutonium were expected to be used in the current generation of nuclear reactors as the needs of our expanding nuclear power industry depleted economically recoverable uranium resources. For the longer term, the recovered plutonium was expected to provide the initial fuel for the next generation of reactors, called breeder reactors.

Some countries with major nuclear power programs are operating, or intend to operate, reprocessing facilities as integral parts of their nuclear power programs. Although the United States government operates reprocessing plants for defense purposes, a number of factors affected the development of a commercial reprocessing industry in this country. These included evolving regulatory requirements, decreases in the anticipated use of nuclear power which lowered the commercial prospects of reprocessing, and the concern that plutonium recovered during reprocessing could be used for nuclear explosives. In 1977, President Carter announced an indefinite deferral of commercial reprocessing in the United States in hopes of discouraging other nations from developing reprocessing capabilities. (See p. 2.)

In October 1981, President Reagan lifted the indefinite deferral on commercial reprocessing and indicated that private industry should take the initiative in beginning any reprocessing ventures. This raised speculation that the industry could be revived, and specifically, that the Barnwell Nuclear Fuel Plant--a privately owned, partially constructed reprocessing plant in South Carolina--could become operational and reprocess spent fuel. Attempts of the Barnwell plant's owners--Allied-General Nuclear Services--to get

the plant commercially operational ended in 1977. Since then the federal government has spent about $89 million at the plant on various research projects and plant maintenance activities. (See p. 5.)

Against this backdrop, the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce (and subsequently the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology) requested GAO to review the status of the Barnwell plant and the potential for it to be completed and put into commercial operation. (See p. 6.)

Reprocessing of commercial spent fuel has been closely tied to long-standing nuclear power issues such as proliferation, development of the breeder reactor, and radioactive waste disposal. Proponents of reprocessing believe it can facilitate the eventual disposal of radioactive wastes and preserve the energy potential in spent fuel for future use. Opponents question whether reprocessing facilitates waste disposal and argue that reprocessing could lead to proliferation of nuclear weapons. This report does not analyze the pros and cons of reprocessing as it relates to these issues. These issues are addressed only to the extent that they may affect the potential for private industry to complete and operate the Barnwell plant as a purely commercial venture for the purpose of reprocessing domestic spent fuel for U.S. utilities.

STATUS OF THE BARNWELL PLANT

The Barnwell Nuclear Fuel Plant is a partially constructed plant valued by Allied-General at about $500 million. The plant was officially closed December 31, 1983. While GAO cannot predict that the plant can be licensed and successfully operated, technical assessments of the plant and GAO discussions with knowledgeable persons within and outside the government disclosed no apparent fundamental problems that currently would prohibit the plant from operating when completed. A number of technical concerns and licensing issues, however, need to be resolved before the plant could operate as a commercial venture. To become fully operational, additional facilities would have to be built, existing facilities modified, and the entire complex licensed by the Nuclear Regulatory Commission. In addition, GAO found that the economic prospect for the plant as a commercial venture is not promising.

Major portions of the Barnwell plant, including the facility that separates the uranium and plutonium from spent fuel, are already constructed. Modifications of these facilities, however, would be needed to eliminate and/or reduce existing technical concerns--such as the questionable operability of specific pieces of equipment and whether the plant can be properly maintained. In addition, other facilities would have to be built--including a facility to solidify the high-level radioactive wastes which would be generated at the plant. The owners of the plant estimate it would cost over $700 million to build the additional facilities and make the necessary modifications. Nuclear industry officials believe it could take as long as 10 years before the plant could be fully operational. (See pp. 9 and 12.)

For the plant to operate as a commercial venture the Nuclear Regulatory Commission would have to issue an operating license. Proceedings for an operating licensing of the plant were terminated in 1977. While Commission staff are not aware of any fundamental problems with existing facilities that would prohibit the plant from being licensed when completed, their review of any application to operate the plant would virtually start over. Previously identified issues, such as effluent controls and safeguard systems at the plant would be examined as part of the review process. Staff of the Commission believe it would take them at least 2 years to complete their technical reviews once they received an application for an operating license. Moreover, attempts to license the plant will probably be contested by public interest groups. As a result, public hearings could be lengthy. (See p. 15.)

To be economical as a commercial venture the Barnwell plant would have to reprocess 1,200 to 1,500 metric tons of domestic spent fuel yearly at a cost that utilities would find lower than the value of the recovered uranium and plutonium. The economic prospects of the Barnwell plant providing domestic reprocessing services at such a cost are not promising. To begin with, plutonium cannot be used as a fuel in commercial nuclear reactors without specific Nuclear Regulatory Commission approval. Proceedings by the Commission to determine, among other things, the environmental, health, and safeguards impacts of the widespread use of plutonium were halted in 1977 in deference to President Carter's nonproliferation policy.

Furthermore, recent industry and government data indicate that even if plutonium could be used as a nuclear fuel, a commercially operated Barnwell plant would be uneconomical. Specifically, Allied-General estimates reprocessing services at the plant would cost from $300 to $350 per kilogram of spent fuel, while industry and government data indicate the combined value of the recovered products in a kilogram of spent fuel to be less than $240. (See p. 18.)

POTENTIAL FOR BARNWELL TO BE OPERATIONAL

Whether commercial spent fuel should ever be reprocessed in the United States depends on one's view of many long-standing issues facing nuclear power. The potential for Barnwell to become operational in a commercial setting, however, is driven by economics in the private marketplace which is closely tied to the future of nuclear power as a domestic energy source. At one time, it was expected that the expanding nuclear power industry would quickly deplete economically recoverable uranium resources, and that commercial reprocessing would be an integral and profitable part of the nation's maturing nuclear power industry. Over the years, however, the domestic nuclear power industry has not grown as anticipated, bringing the timing and need for reprocessing as a strictly commercial venture into question.

It is difficult to quantify and predict when, or if, reprocessing might become a profitable business venture because of the uncertain future of nuclear power. If one expects nuclear power to be a major long-term source of electricity, then commercial reprocessing should eventually be economical as uranium resources become scarce. When this might occur, however, depends on a number of assumptions, including nuclear power's growth rate during the next century. On the other hand, if one expects that nuclear power will be phased out before uranium ore supplies are seriously depleted, then reprocessing, as a commercial venture, may not have a role within the nuclear power industry. (See p. 21.)

In regard to the Barnwell plant, there appears to be little interest in operating the plant as a commercial venture. GAO believes this lack of interest is due, in part, to the uncertain outlook for nuclear power. In addition, industry representatives GAO contacted believe the federal

government would have to address three issues before they would seriously consider any commercial reprocessing venture, including Barnwell.

--Will owners of domestic nuclear powerplants be permitted to use plutonium recovered from commercial reprocessing in manufacturing nuclear fuel? This is an important issue because of its effect on the economic prospects of commercial reprocessing. The conditions, if any, under which plutonium can be used are a matter for decision by the Nuclear Regulatory Commission. Such a decision would permit a more definitive analysis of the economic potential of commercial reprocessing. (See p. 23.)

--What is an acceptable waste form for disposing of the high-level radioactive wastes produced from commercial reprocessing operations? Although federal regulations require that liquid high-level radioactive wastes from commercial reprocessing be solidified within 5 years after being generated, the federal government has not specified an acceptable solidified form. A solidified waste form must first be selected by the Department of Energy, which is responsible for disposal of highly radioactive wastes from commercial nuclear powerplants. The Department must then demonstrate that the waste form and its packaging in a repository meet the Nuclear Regulatory Commission's regulations. (See p. 24.)

--Is the federal government willing to protect a future commercial reprocessing venture from losses stemming from changes in government policy? Many nuclear industry representatives believe that President Carter's indefinite deferral of commercial reprocessing ended the commercial reprocessing industry in the United States and reversed the federal government's long-standing policy of encouraging the industry. The representatives believe that some form of protection is needed to protect industry's investment from future changes in government policy. Such protection, however, could move reprocessing beyond a strictly commercial venture. (See p. 26.)

GAO emphasizes that obtaining answers to these questions that are favorable to commercial reprocessing will not necessarily lead industry to complete and operate the Barnwell plant or to pursue another reprocessing venture. It would only enable industry to analyze the current and future

prospects for commercial reprocessing with a higher degree of certainty.

AGENCY COMMENTS

GAO did not obtain official agency comments on this report. GAO did, however, discuss the information presented in the report with representatives of the Department of Energy and the Nuclear Regulatory Commission. These officials were in general agreement with the information presented in the report.

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ABBREVIATIONS

AEC	Atomic Energy Commission
DOE	Department of Energy
EPRI	Electric Power Research Institute
GAO	General Accounting Office
GESMO	Generic Environmental Statement on Mixed-Oxide Fuels
kg	kilograms
NFS	Nuclear Fuel Services, Inc.
NRC	Nuclear Regulatory Commission

CHAPTER 1

INTRODUCTION

Nuclear fuel after it has fissioned and is discharged from a nuclear powerplant is called spent fuel. This spent fuel still contains significant amounts of uranium (about 95 percent) which can be reused--after enrichment[1]--as nuclear fuel and small amounts of plutonium (about 1 percent) which can also be used as nuclear fuel. The remaining portion of the spent fuel (about 4 percent) consists of highly radioactive fission products--commonly referred to as high-level radioactive waste. The uranium and plutonium can be chemically separated and recovered by a process commonly referred to as reprocessing.

Reprocessing can play an important role in the nuclear fuel cycle[2] for those nations which view nuclear power as a major and long-term source of energy and are concerned about the long-term supply of uranium. To begin with, a nation could extend its supply of indigenous uranium ore and/or reduce its reliance on energy imports by recycling the uranium and plutonium recovered through reprocessing back into nuclear fuel for use in conventional nuclear powerplants. Secondly, the recovered plutonium could provide the initial fuel for another generation of nuclear powerplants--namely, breeder reactors. Breeder reactors can simultaneously generate electricity and produce more usable nuclear fuel than they consume.[3] Compared with today's conventional power reactors, breeders coupled with reprocessing could increase the energy utilization of uranium by a factor of about seventy. Because of its potential to extend the role of nuclear power, reprocessing capabilities have been developed in several countries.

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[1]Uranium enrichment involves separating the two principal forms of uranium found in nature (U-235 and U-238) to obtain a product which has a higher concentration of U-235 and is therefore more fissionable. Uranium fuel for a nuclear powerplant is typically enriched so it contains about 3 percent U-235. Typical spent fuel contains about 0.8 percent U-235.

[2]The nuclear fuel cycle consists of a number of processes, beginning with the mining and milling of uranium ore and ending with final disposal of either the high-level radioactive waste from reprocessing or spent fuel.

[3]In breeder reactors, natural uranium can be converted into plutonium. After the breeder fuel and irradiated natural uranium are discharged from the reactor, it is reprocessed to extract plutonium converted from the natural uranium and residue plutonium from the initial fueling. This plutonium can then be used as more breeder fuel. The cycle can be repeated until natural uranium supplies are exhausted.

PERSPECTIVE ON COMMERCIAL REPROCESSING IN THE U.S.

In the early days of the nation's commercial nuclear power program, government and industry officials viewed commercial reprocessing as an integral part of the nuclear fuel cycle.[4] In 1966, Nuclear Fuel Services, Inc. (NFS) began operating the first commercial reprocessing plant in the U.S. at West Valley, New York. Several other commercial ventures, including the construction of a large reprocessing plant in South Carolina (the Barnwell Nuclear Fuel Plant), were soon initiated by other private companies. (See app. I for a listing of commercial reprocessing ventures in the U.S.)

Commercial reprocessing in the U.S., however, was short-lived. In 1976 NFS announced it would be leaving the reprocessing business. None of the other ventures, including the Barnwell plant, ever became operational. There are a number of factors that affected commercial reprocessing ventures in the U.S. which are important as a backdrop in understanding the current issues surrounding reprocessing. They include

--evolving regulatory requirements governing the construction and operation of reprocessing plants,

--uncertainty regarding the future permissible use of plutonium as a commercial fuel,

--concern that worldwide reprocessing of spent fuel and recovery of plutonium could result in the proliferation of nuclear weapons, and

--decreases in the anticipated growth of nuclear power since 1972 which changed the economic prospects for commercial reprocessing.

Government regulatory requirements can be an important factor affecting the business prospects for commercial reprocessing. According to nuclear industry officials, government regulatory actions, such as more stringent seismic criteria for reprocessing plants, led to the closing of the West Valley plant. In 1972, NFS ceased reprocessing at West Valley to expand the plant's capacity. Then, in September 1976, however, NFS announced it would leave the reprocessing business because compliance with federal regulatory requirements would cost over $500 million, a figure which, according to NFS, would make its plant uneconomical. Additionally, nuclear industry representatives told us that there was a general concern within the industry about moving ahead with commercial reprocessing in an environment where future government

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[4]The federal government has been operating reprocessing plants to meet the needs of the defense programs since the 1940's.

regulations could be imposed that could substantially raise the cost of operating a commercial reprocessing business.

In the mid-1970's uncertainties about the permissible use of plutonium as a fuel source[5] began to surface. In February 1974, the former Atomic Energy Commission (AEC) announced that prior to any decision on the widespread use of fuels containing plutonium (mixed oxide) a Generic Environmental Statement on Mixed Oxide Fuels (GESMO) would be prepared. This statement was to contain, among other things, an indepth evaluation of the health, safety, and environmental impacts of using mixed oxide fuels. The final statement and subsequent decision would also take into consideration a detailed analysis of alternative programs for safeguarding plutonium--that is, preventing its illicit use for nuclear explosives or toxic dispersal. The responsibilities of finishing the GESMO proceedings and arriving at a final decision on the use of mixed oxide fuels were transferred to the Nuclear Regulatory Commission (NRC) when it was created in 1975. Although a substantial amount of work was done toward completing GESMO, NRC's deliberations on the matter were halted in December 1977 in deference to President Carter's nonproliferation policy (see below). NRC has not resumed its deliberations since there has been no request or industry initiative showing a demonstrated need to resolve the GESMO matter. Hence, it is still uncertain under what conditions, if at all, plutonium would be permitted to be used in nuclear fuel on a widescale basis.

In 1976, concern that commercial reprocessing could lead to the proliferation of nuclear weapons became a major public issue. This concern centered around the possibility that plutonium recovered in reprocessing could be used to produce nuclear explosives. Presidents Ford and Carter were both concerned that allowing commercial reprocessing in the U.S. could encourage other countries to reprocess their spent fuel and thus acquire plutonium which could be fabricated into nuclear explosives. This proliferation concern was the principal reason why in October 1976, President Ford said that reprocessing should not proceed absent a conclusion that proliferation risks could be overcome, and on April 7, 1977, President Carter announced a nuclear nonproliferation policy calling for, among other things, the indefinite deferral of commercial reprocessing and recycling of plutonium in the United States. The President hoped this action would set an example for other nations to forego commercial reprocessing.

Finally, in the mid-1970's the overall economic viability and long-term business prospects began to change for commercial reprocessing. One major reason for the changing prospects was a result

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[5]Today's conventional light water reactors are fueled with enriched uranium. These reactors can also operate on fuel made from plutonium and uranium.

of a slowdown in the growth of nuclear power. In this regard, during the late 1960's and early 1970's government officials were concerned that domestic uranium supplies alone could not meet the fuel requirements of the rapidly growing nuclear industry. Thus, as domestic uranium prices rose commercial reprocessing would become more lucrative for private industry. The high growth rate never materialized, however, and the economic outlook of commercial reprocessing for both the short- and long-term became less certain. Chapter 3 discusses the decrease in the anticipated growth of nuclear power, and how it relates to commercial reprocessing.

To complete a perspective on commercial reprocessing in the U.S. it is important to note two important developments that occurred in the 1980's. First, on October 8, 1981, President Reagan lifted the indefinite deferral policy of President Carter. In doing so, the President indicated that private industry should take the initiative in beginning any reprocessing ventures. Second, the Nuclear Waste Policy Act of 1982, Pub. L. No. 97-425 (1983) was enacted. This act sets up a timetable for disposing of spent fuel and high-level radioactive wastes in federal repositories. Although the act does not specifically address commercial reprocessing, it does give the Department of Energy (DOE) flexibility in implementing portions of the act that can possibly affect reprocessing. For example, DOE will determine how high-level radioactive wastes generated from reprocessing activities must be solidified and packaged before it accepts such wastes for final disposal. DOE will also establish a fee for disposing of such wastes. Such factors, according to many nuclear industry representatives, could affect the cost of reprocessing services.

THE BARNWELL NUCLEAR FUEL PLANT

Construction of the Barnwell Nuclear Fuel Plant in South Carolina--which is owned by Allied-General Nuclear Services (Allied-General)--began in 1971. After the 1977 announced deferral of commercial reprocessing, NRC issued an order in December 1977 terminating its proceedings on Allied-General's application for an operating license.[6] Many nuclear industry representatives, government officials, and members of the Congress, however, did not want to foreclose on the reprocessing

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[6]On March 16, 1983, the owners of the Barnwell Nuclear Fuel Plant filed suit against the federal government in the United States Claims Court in Washington, D.C. The claim alleges that actions of the U.S. government in 1977, eliminated the opportunity to operate the plant and constitutes the taking of property without just compensation. (Allied-General Nuclear Services v. United States, No. 146-83). The U.S. filed an answer on May 23, 1983. No motions or briefs have been filed to date and the case is pending. GAO takes no position on the issues or merits of this law suit.

option at least until further studies on alternative nuclear fuel cycles, proliferation risks, and the safeguarding of plutonium could be completed. The Barnwell plant became the focal point for keeping the reprocessing option alive. Over the last 5 years, DOE has spent about $89 million at the Barnwell plant for various research and development activities related to reprocessing, plant safeguards, fuel handling, and plant maintenance. Federal funding ended at the plant in July 1983 when the federal contracts expired.

After President Reagan lifted the reprocessing deferral, some government officials and representatives of the nuclear industry speculated that the Barnwell plant could operate as a commercial venture. In this regard they cited possible benefits to making the Barnwell plant operational. It could

--help alleviate spent fuel congestion. Some utilities are beginning to use up their existing spent fuel storage capacity. This problem could eventually become critical and possibly even lead to shutting down reactors. An operational reprocessing plant the size of Barnwell could help alleviate this congestion.

--provide plutonium for the government's civilian nuclear program. The federal government requires plutonium for its current civilian breeder reactor program which includes operation of the Fast Flux Test Facility. If Barnwell were operational it could supply plutonium for the government's civilian nuclear program.

--provide operational experience and data on commercial reprocessing. An operational reprocessing plant would provide actual operating data on the economic, technical, safety, and institutional aspects of commercial reprocessing.

--demonstrate advanced systems aimed at preventing the theft, loss, or diversion of nuclear material. The successful demonstration of such systems could provide better protection of nuclear material in the U.S. and possibly influence other countries, which are reprocessing spent fuel, to adopt them.

Notwithstanding such possible benefits, some government officials and others have raised a number of possible drawbacks in getting the Barnwell plant operational.

--Some countries which do not currently have plans to reprocess spent fuel may view an operational Barnwell plant as a sign of U.S. acceptance that reprocessing is a necessary step in the nuclear fuel cycle. This could encourage other countries to acquire reprocessing capabilities and thus have access to plutonium and possibly nuclear explosives.

--Making Barnwell operational may require large government subsidies, either directly or indirectly, since the economic propsects of reprocessing have changed since the early 1970's.

--A fully operational Barnwell facility would produce far more plutonium than needed for the U.S. civilian breeder reactor program. This raises questions concerning how to store and who would store the excess plutonium, who would pay storage and safeguards costs, and how it might eventually be used.

--The plant could create potential environmental and safety problems in that large quantities of toxic and/or radioactive materials would be handled and stored there.

As one can see from some of the potential benefits and drawbacks, the future operation of the Barnwell plant would likely be a controversial issue.

OBJECTIVES, SCOPE, AND METHODOLOGY

On April 9, 1982, the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, requested[7] that we respond to a list of questions relating to the Barnwell Nuclear Fuel Plant. As agreed with the Subcommittee staff we focused our work on (1) the usefulness of federally funded activities at the Barnwell plant and (2) the status of Barnwell and its potential to become operational. We also agreed to provide the Chairman with a separate report on each area. The first report, entitled Usefulness of Federally Funded Activities at the Barnwell Nuclear Fuel Plant (GAO/RCED-83-128), was issued on May 9, 1983. This second report addresses the status of the Barnwell plant and its potential to become operational.

In determining the plant's overall status, our work was aimed at providing a perspective on the time, cost, problems, and practicality of getting the plant operational as a commercial venture. To accomplish this, we focused our work on determining the (1) construction status, including the capital invested, and cost to complete, (2) technical status, including identifying potential technical problems or concerns with the plant, (3) licensing status, including steps necessary to license the plant and identifying the problems that might arise, and (4) economic status for the Barnwell plant and reprocessing in general.

In determining the plant's construction status, we relied initially on information supplied by Allied-General concerning the capital invested and the estimated cost to complete. We then

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[7]The Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology, sent us a similar request on May 24, 1982.

selectively verified specific data as well as Allied-General's rationale for their estimates. We also compared these estimates with information we had acquired from DOE and non-government organizations to judge the reasonableness of Allied-General's estimates. Finally, through discussions with various government and non-government organizations, we attempted to identify specific factors which might affect the cost estimates.

In addressing the technical issues, we examined and analyzed a broad array of information, including research and development reports by DOE and Allied-General; studies and/or correspondence from Allied-General, DOE, NRC, and various private industry groups such as Bechtel Inc., and the Electric Power Research Institute (EPRI). We supplemented this information with the views of knowledgeable persons within and outside the government who were familiar with the Barnwell plant. We also visually inspected the plant and examined and analyzed Allied-General's maintenance practices and records.

In determining the licensing status, we relied primarily on the information and views of NRC, which has responsibility for the licensing permits at Barnwell. Among other things, we reviewed NRC's licensing documents and public hearings on Allied-General's application for an operating license. We supplemented this information with the views of DOE, utilities such as Florida Power and Light, Yankee Atomic, and Southern California Edison, and various public interest groups, including the Energy Research Foundation and Environmentalists, Inc.

Finally, in examining the economic status of commercial reprocessing at the Barnwell plant, we reviewed a wide variety of studies, professional papers, and government reports that have been done over the last several years. Although we primarily used economic data developed by the nuclear industry, we independently checked key portions of the data with our own calculations based on information acquired from DOE. We supplemented this information with the views of utilities regarding their potential interest in having their spent fuel reprocessed. Our economic analysis was limited to commercial reprocessing of domestic spent fuel for utilities in the United States. Chapter 2 discusses the construction, technical, licensing, and economic status of the Barnwell plant.

Our work in determining the potential for making the Barnwell plant operational focused on identifying and analyzing the issues surrounding the Barnwell plant becoming a commercial enterprise. To accomplish this, we obtained the views of officials from private industry, utilities, DOE, NRC, the Office of Science and Technology Policy, national laboratories, public action groups, various state governments, and other knowledgeable people familiar with reprocessing. We also analyzed a wide variety of information supplied by these officials and/or organizations. We also drew upon and updated information developed in our prior reports. The

most significant reports include (1) An Evaluation of Federal Support of the Barnwell Reprocessing Plant and the Department of Energy's Spent Fuel Storage Policy (EMD-78-97, July 20, 1978); (2) Nuclear Fuel Reprocessing and the Problems of Safeguarding Against the Spread of Nuclear Weapons (EMD-80-38, Mar. 18, 1980); (3) Is Spent Fuel Or Waste From Reprocessed Spent Fuel Simpler To Dispose Of? (EMD-81-78, June 12, 1981); (4) The Liquid Metal Fast Breeder Reactor--Options For Deciding Future Pace and Direction (GAO/EMD-82-79, July 12, 1982); and (5) Usefulness of Federally Funded Activities at the Barnwell Nuclear Fuel Plant (GAO/RCED-83-128, May 9, 1983). Chapter 3 analyzes the major issues surrounding the operation of Barnwell as a commercial venture.

We did not obtain official agency comments on this report at the request of the Chairman of the Subcommittee on Energy Conservation and Power. With this exception, we conducted our audit in accordance with generally accepted government audit standards. We did, however, discuss the information presented in the report with representatives of DOE and NRC. We also discussed the information presented with officials of Allied-General. These officials were in general agreement with the information presented in the report. Audit work was performed during the period October 1982 through September 1983.

CHAPTER 2

STATUS OF THE BARNWELL NUCLEAR FUEL PLANT

For years the Barnwell Nuclear Fuel Plant has been a focal point in debating the advantages and disadvantages of commercial reprocessing in the United States. This chapter presents information on the construction, technical, licensing, and economic status of the Barnwell plant to provide a perspective on the time, cost, problems, and practicality of getting the plant operational as a commercial venture. While we cannot predict whether the plant can be licensed and successfully operated, technical assessments of the plant and our discussions with knowledgeable persons within and outside the government disclosed no apparent fundamental problem that would prohibit the plant's operation. A number of technical concerns and licensing issues, however, need to be resolved before the plant could operate. Finally, its economic prospect as a commercial venture is not promising.

CONSTRUCTION STATUS

Barnwell was the first large-scale commercial reprocessing venture in the United States. It is designed to reprocess 1,500 metric tons of nuclear spent fuel per year[1] and, if completed, would consist of five major facilities:

--a spent fuel storage facility capable of storing between 400 and 750 metric tons of spent fuel;[2]

--a separation facility to chemically process commercial nuclear spent fuel assemblies into liquid uranium nitrate, liquid plutonium nitrate, and liquid high-level radioactive wastes;

--a uranium hexafluoride facility to convert the liquid uranium nitrate into uranium hexafluoride for subsequent enrichment;

--a plutonium conversion facility to convert the liquid plutonium nitrate to a solid and store it for eventual use as a light water reactor fuel or in breeder reactors; and

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[1]A typical operating nuclear reactor discharges about 30 metric tons of spent fuel a year.

[2]The spent fuel storage facility can be modified to accommodate about 1,300 metric tons of spent fuel according to Allied-General.

--a waste solidification facility to solidify the liquid wastes and temporarily store them before shipment to a permanent repository.

Construction of the spent fuel storage facility and separation facility was begun in 1971. These two facilities have been essentially completed. In January 1974, Allied-General began constructing the uranium hexafluoride facility. This facility was completed and checked out by the end of 1976. The two remaining facilities necessary to complete the plant complex--the plutonium conversion and waste solidification facilities--were never constructed. The existing facilities have been maintained over the years in connection with specific research and development activities that have been carried out.

Significant amounts of money would be required to make the plant fully operational. The following table shows Allied-General's estimates of the existing plant's cost and the cost to complete it.

Estimated Cost of the Barnwell Nuclear Fuel Plant If Completed

Facility	Cost of the existing facility[a]	Estimated cost to complete[b]	Total
	(In thousands of 1982 dollars)		
Spent fuel storage facility[c]	$ 46,984	$ 2,500	$ 49,484
Separation facility	354,663	23,900	378,563
Uranium hexafluoride facility	43,019	5,300	48,319
Plutonium conversion facility	19,872	175,000	194,872
Waste solidification facility and solid and liquid wastes handling	22,030	345,000	367,030
Miscellaneous costs[d]	--	153,300	153,300
Total	$486,568	$705,000	$1,191,568

[a]The $486.6 million shown represents the escalation of Allied-General's original construction cost of about $214 million, due to inflation, in constructing the plant.

[b]This cost includes modifying existing facilities as well as new construction.

[c]Does not include the cost to expand capacity of this facility.

[d]This cost includes a variety of ancillary costs necessary to operate the plant, such as enhancing physical security and safeguard systems and enlarging the administration facilities.

As the above table shows, the existing plant is valued by Allied-General at nearly $500 million and is estimated by Allied-General to cost an additional $700 million to complete. The actual cost to make the Barnwell plant fully operational, however, could be substantially higher. For example, the above table does not include a krypton[3] recovery system. Current

[3]Krypton is an inert gas present in small quantities in the atmosphere. Some environmentalists and government officials are concerned about the potential build up in the atmosphere of radioactive krypton.

Environmental Protection Agency regulations set standards for the amount of krypton generated by the fission process after January 1, 1983, that may enter the environment. While there is enough spent fuel generated prior to that date to operate Barnwell for many years, such a recovery system might eventually be required and could cost as much as $100 million according to Allied-General officials. Finally, the waste solidification facility, in terms of size and capabilities, would be a first-of-a-kind, and thus may be prone to cost overruns.

Another important aspect in regard to the construction status is how long it would take to put the plant into operation. This depends on many factors such as how the remaining construction of the plant is financed, the length of the licensing process, and how long it would take to negotiate contracts with utilities to reprocess spent fuel. If all facilities were completed and checked out before the plant began reprocessing spent fuel, Allied-General estimated in 1983 that it could take about 6 years before the plant could become operational. Other nuclear industry representatives we contacted were not as optimistic. They believe it could take 8 to 10 years before Barnwell could operate.

Finally, it should be recognized that these costs and time frame estimates for making the Barnwell plant operational have changed with the closing of the plant. An Allied-General representative told us the plant officially closed December 31, 1983. Virtually all technical personnel have been dismissed, equipment such as boilers and compressors sold, and all maintenance of the plant stopped. According to this representative, it would cost about $20 million to replace the equipment sold. The closure of the plant, he informed us, adds 2 to 3 years onto the time frame necessary to make the plant operational.

TECHNICAL STATUS

The Barnwell plant would use an adaptation of the Purex extraction process used for years in U.S. government reprocessing plants[4] and in commercial reprocessing plants outside the U.S. The Barnwell plant, in addition to being the largest commercial reprocessing plant ever constructed, incorporates a number of equipment and design features aimed at improving its economic operation. For example, it incorporates equipment, systems, and/or design features which have not been tested extensively for continual operation in a large-scale commercial plant. Thus, the plant can be considered unique in size and design.

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[4]The Purex extraction process utilizes organic liquid solvent to extract uranium and plutonium from an acid nitrate solution. The process is currently being used at the Government's Savannah River complex as well as other reprocessing plants in the U.S. to develop nuclear material for military needs.

The Barnwell plant has been the subject of a number of technical and/or utilization studies both by government and non-government entities.[5] Our review of previous studies, supplemented by the views of industry representatives and government officials, did not reveal any fundamental technical problems that would prohibit completion and operation of the Barnwell plant. However, two important concerns were identified that relate to the safe and/or economic operation of the plant.

The first concern involves the Barnwell plant design. The plant was designed and built employing a combination of remote and contact (manual) maintenance systems. This design feature has been a major area of concern in some studies. If a leak develops or equipment fails in an area of the plant that is not remotely maintainable, the plant might have to be shut down for an extended period to effectively decontaminate that portion of the plant before repair crews would be allowed access to correct the problem. This problem situation is further complicated in some areas of the plant because of the density of equipment and piping. In these areas, decontamination efforts could be difficult. In addition, at least one study was critical of the plant's design because of thin biological shielding in certain areas.

Allied-General officials maintain that the plant was designed to be maintenance-free and they do not expect any serious leaks or equipment failures to occur. Nevertheless, they believe that the maintenance-free concept can be improved upon. Both a Bechtel-EPRI study of 1981 and a draft EPRI study of 1978 (see footnote 5 for titles of these studies) seem to concur with Allied-General's view. These studies do not criticize the design of the plant but do recommend a number of changes that would facilitate repair work on specific pieces of equipment and reduce the likelihood of leaks.

Allied-General has identified a number of modifications that would be undertaken before the plant becomes operational. Many of

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[5]The two most comprehensive non-government studies appear to be (1) a draft Technical Planning Study dated March 1978 by EPRI and (2) An Assessment of the Operability and Maintainability of the Barnwell Nuclear Fuel Plant, dated December 1981 by Bechtel National, Inc., and EPRI. The government has conducted a number of studies evaluating the plant from more of a functional aspect. These include (1) a Barnwell Nuclear Fuels Plant Applicability Study, dated April 1978, by DOE and (2) an Evaluation of Utilization of Barnwell Nuclear Fuel Plant in Support of the U.S. Breeder Reactor Reprocessing Program, dated March 1981, by Oak Ridge National Laboratory. Less comprehensive studies of the plant have been conducted by Argonne National Laboratory in December 1980 and the Savannah River Operations Office of the DOE in January 1979.

these modifications are aimed at correcting potential problem areas identified in previous studies. Some of the more significant proposed modifications that would be undertaken include

--removing equipment, identified in previous studies as possibly requiring maintenance, to areas of the plant where it can be more easily worked on;

--replacing all flanges and valves with solid piping;

--adding additional shielding where necessary throughout the plant; and

--adding additional decontamination systems in portions of the plant.

In addition, Allied-General officials told us that the plant, at least initially, would reprocess only spent fuel aged a minimum of 3 years. This would significantly reduce the overall radiation levels within the plant.

The second concern involves the operability of specific equipment and/or systems. Some previous studies and/or people familiar with the plant raised potential problems and/or concerns ranging from the front-end shear system (discussion to follow) to the use of plastic plates and carbon steel bolts in the plant which might corrode relatively quickly. Allied-General representatives are familiar with the problems and believe many are easily correctable. For example, they said they would replace all plastic plates and carbon steel bolts with more corrosion-resistant material if the plant was to become operational.

Nevertheless, we identified three important examples of equipment and/or systems as potential problems and/or concerns. These potential problems and/or concerns could impair the operation of the plant. The equipment and/or systems, their purposes, and the potential concerns are shown in the following table.

Examples of Equipment/Systems Raising Technical Concerns

Equipment/ systems	Purpose	Concern
Front-end shear system[a]	This system chops up spent fuel assemblies so that the residual fuel can be leached out with nitric acid.[a]	Possible short life-expectancy.
Centrifugal contactor	This device is used to collect and separate radioactive waste from the uranium and plutonium in the nitric acid solution.	Equipment may be prone to plugging and breakdown.
Electropulse column	This device is used to make the plutonium insoluble in the acid solution and thereby facilitate its separation from uranium.	Device may not work as designed.

[a]The front-end shear system is a critical component of the plant, because nitric acid will not dissolve commercial spent fuel cladding, thus requiring the fuel rods to be chopped up so that residual fuel inside can be leached out.

Allied-General officials point out that they would conduct extensive testing of the plant's equipment prior to operation. If these concerns turned out to be serious problems, corrective action would be taken. However, they point out that a front-end shear system has been used for years by the French Government in its smaller reprocessing plant. Furthermore, they do not expect the shear to last the life of the plant but only 5 to 10 years.[6] In regard to the other two items mentioned in the previous table, Allied-General officials agree that they could have trouble with these systems working properly but added these systems can be by-passed by using back up systems in the plant, or replaced if necessary. Furthermore, Allied-General officials told us that all these systems are remotely replaceable.

LICENSING STATUS

Licensing activities for the Barnwell plant began November 6, 1968, with an application for construction permit and continued intermittently for almost 10 years. In 1977 the proceeding on Allied-General's application for an operating license was terminated by order of the NRC along with the GESMO proceedings (NRC's

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[6]Allied-General representatives told us they already have a replacement shear.

deliberations on the use of mixed oxide fuels). As a result, any future owners of this plant would have to submit an operating license application for the Commission to reopen the proceedings. NRC officials estimate it would take at least 2 years to complete its staff's health, safety, environmental, and safeguards reviews after receipt of the application. As part of NRC's licensing process, time would likely be required for public hearings.

AEC granted a construction permit to Allied-General covering the separation and fuel receiving and storage facility on December 18, 1970. Construction of these facilities was underway when Allied-General requested, in October 1973, that the construction permit be amended to an operating license. Within a matter of months several environmental groups intervened in the proceeding and opposed the continuation of the construction permit and issuance of an operating license. These groups cited a number of reasons in opposing the operating and further construction of the separation and spent fuel storage facilities. These include the health risks associated with the release of tritium[7] and krypton into the air, the need for equipment to control such emisssions, the danger that could result from a serious earthquake, and the possibility of accidental releases of radioactivity resulting from an explosion, seepage, or transportation accident. Also, during the hearings other concerns were raised. For example, in a letter to the AEC, the then Governor of Georgia recommended the installation or development of equipment to control krypton and tritium releases and the development of an emergency action plan. The AEC and follow-on NRC reviews also raised some concerns about safeguarding plutonium to prevent its diversion for other purposes. The NRC staff in general believed additional protective measures at the plant were necessary because of the large quantities of plutonium to be recovered and stored on site.

In December 1977, the NRC, taking into consideration presidential views and public comments on the future of plutonium recycle activities, issued an order to terminate the proceedings on pending or future plutonium recycle-related license applications. Thus, the operating license application proceeding for the Barnwell separation facility was terminated. A subsequent NRC Memorandum of Decision (May 1978) denied the operating license application, but indicated that this action was to be viewed as

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[7]Tritium is a radioactive isotope of hydrogen having a half-life of about 13 years.

nonprejudicial in the event the Commission permitted any future reconsideration of an operating license.[8]

If licensing proceedings were to be reopened, Allied-General representatives told us, they foresee no fundamental problem in obtaining a license to reprocess spent fuel. They added that they believe many of the concerns initially raised about the plant have been addressed. For example, they told us the Barnwell plant has the most advanced nuclear material safeguard and material accounting systems in the world. Also, they pointed out that the plant would be modified and operated in such a manner as to reduce overall radiation levels throughout the plant. They told us they can support their contention that the plant can be safely operated with data gathered in their limited operational testing of the plant.

Although Allied-General representatives are confident that the plant could be licensed, opposition from the original intervenors and others can be expected. Many of the original intervenors are still concerned about the environmental issues they initially raised. For example, the spokeswoman for the original intervenors during the licensing hearings told us she does not believe any of the original contentions have been resolved. She added that more information is now available to further support some of these concerns. In addition, opposition from new groups is likely. Representatives from the Energy Research Foundation and the Palmetto Alliance--both located in South Carolina--told us they would likely oppose any future plans to operate the plant. One group told us that they have set up a contingency fund to oppose the startup of Barnwell.

NRC officials told us they were not aware of any fundamental problem with the existing facilities which would prohibit licensing the plant. They pointed out, however, that any future applicant interested in operating the plant would have to submit all the necessary data, including appropriate safety analysis and environmental reports. These NRC officials told us that their review of the application and all associated documents would virtually start over since a new review team would have to be pulled together. Their review would include examining earlier unresolved licensing issues such as effluent controls, safeguard systems, and material control accountability. Their review would also include their own independent analyses of potential safety, environmental, and safeguard issues. Overall, they believe the licensing reviews of the Barnwell plant would take at least 2 years after receipt of an updated application. Public hearings, as part of the licensing process, would likely be required.

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[8]NRC did not make any judgments on the technical merits of the plant. Moreover, NRC action did not affect the possible use of small quantities of mixed oxide fuels for experimental purposes.

ECONOMIC STATUS

Most simply put, reprocessing is considered economical when the value of the recovered uranium and plutonium from the commercial spent fuel is greater than the cost to have the spent fuel reprocessed. In the case of a fully commercial Barnwell plant this implies reprocessing 1,200 to 1,500 metric tons of domestic spent fuel yearly at a cost that utilities would find lower than the value of the recovered products for use as fuel. The prospects of the Barnwell plant providing domestic commercial reprocessing service at such a cost are not promising.

As a nuclear powerplant generates electricity, the fissionable uranium is gradually being depleted and small quantities of plutonium produced. Eventually the fuel can no longer efficiently sustain a nuclear reaction and is removed. This spent fuel contains some plutonium which is fissionable and uranium which is slightly enriched above the level of natural uranium (see footnote 1, on page 1). To assess the economic viability of recovering plutonium and uranium for use as nuclear fuel, many factors have to be considered and assumptions made in quantifying the factors. Some important factors include the cost of reprocessing services, the future growth of nuclear power, uranium supplies, the cost to fabricate and transport fuel containing plutonium (mixed oxide), and the values of recovered uranium and plutonium.[9] Some of these factors--such as the cost to fabricate mixed-oxide fuel--are difficult to precisely specify without a history of significant commercial use. As a result, assessments of the economic viability of commercial reprocessing have varied.

Prior to 1980, many studies on reprocessing had indicated that the recovery of uranium and plutonium to be economical.[10] For example, a 1979 study by Bechtel National, Inc., entitled An Assessment of LWR Spent Fuel Disposal Options, estimated, in 1979 dollars, the uranium recovered from a kilogram (kg) of spent fuel would be worth $130 and the recovered plutonium from a kg of spent

[9]The value of recovered uranium can be estimated from the amount of natural uranium and enrichment services saved if the recovered uranium was used in making nuclear fuel. Similarly, a value for plutonium can be estimated from the amount of natural uranium and enrichment services saved if plutonium was used in the making of nuclear fuel.

[10]These include Benefit Analysis of Reprocessing and Recycling Light Water Reactor Fuels (ERDA-76/121, Dec. 1976); Nuclear Fuel Cycle Closure Alternatives (Allied-General, Apr. 1976); Evaluation of Fuel Cycle Options for Plutonium Utilization (Battelle Columbus Labs., May 1977); Economic Analysis of LWR Fuel Cycles (Savannah River Labs., May 1977); and An Assessment of LWR Spent Fuel Disposal Options (Bechtel National, Inc., July 1979.)

fuel would be worth $210. The study, because of the value estimated for the recovered products, also indicated that reprocessing was economically attractive for a plant similar to Barnwell. Since 1979, however, a number of factors associated with assessing commercial reprocessing have continued to change. For example, there has been a significant drop in the price of uranium[11] which affects the value of the recovered products and accordingly prospects for commercial reprocessing. In a letter to DOE, dated September 30, 1983, Bechtel National, Inc., estimated the value of the recovered products in a kg of spent fuel--both plutonium and uranium--to be worth less than $240. DOE data also shows the recovered products to be worth less than $240. The prospects of a commercial Barnwell plant providing reprocessing services at or below $240 per kg is not promising since Allied-General officials estimate a commercial Barnwell plant could only provide reprocessing services at a cost of $300 to $350 per kg of spent fuel.

Some nuclear industry and government officials believe other factors can make reprocessing more economically attractive. These factors include (1) a utility's desire to avoid spent fuel storage costs and (2) the eventual cost difference between disposing of high-level waste from reprocessing versus spent fuel. While these factors may eventually have a positive impact on the economics of reprocessing, our review did not disclose that they can now substantially affect the economics of a Barnwell scale plant in a commercial setting. For example, in regard to spent fuel storage, DOE issued a report entitled Spent Fuel Storage Requirements dated January 1983, which indicates utilities may only begin having a serious spent fuel storage problem in the early 1990's. In regard to any cost differential between disposing of high-level waste from reprocessing versus spent fuel, DOE has not exactly specified how and where it will dispose of either. Hence, it is difficult to calculate what, if any, disposal cost difference between the two will result.

Finally, we believe any discussion of commercial reprocessing cannot overlook the practical matter that plutonium cannot be used as a nuclear fuel in today's nuclear reactors on a widespread basis. (See page 3.) This is an important consideration in examining the economic status for commercially operating the Barnwell plant. In a typical kg of spent fuel, the plutonium recovered is usually considered to be potentially worth more than the recovered uranium.[12] The recovered uranium from a typical kg of spent fuel, taking into consideration current enrichment and uranium ore

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[11]The 1979 Bechtel study priced natural uranium at $43/lb. (1979 dollars). In 1983, natural uranium sold for less than $25/lb.

[12]This is because the recovered plutonium has a much greater potential energy yield than the uranium.

prices, would be worth less than $100. This is clearly uneconomical compared to the cost to have the fuel reprocessed ($300 to $350 per kg of spent fuel according to Allied-General).

It is unlikely the economic status for commercial reprocessing that involves only the recycling of uranium at the Barnwell plant will change in the near future. Based on data provided by DOE, it appears that the price of uranium would have to more than quadruple--from less than $25/lb. to about $100/lb.--before the value of recovered uranium reaches a breakeven with the cost of reprocessing services at a fully operational commercial Barnwell plant. This does not appear likely any time in this century in view of DOE's estimates of the (1) future use of nuclear power by the year 2000 and (2) domestic uranium ore reserves that are known to and/or probably exist. Specifically, DOE estimates that about 132 gigawatts[13] of nuclear power are likely to be deployed by the year 2000 and that there is probably over 3 million tons of domestic uranium ore which is recoverable at $100/lb. or less. Since this is more than sufficient uranium to meet the expected fuel requirements of the domestic nuclear industry well beyond the year 2000,[14] it does not appear likely based on DOE data that domestic uranium prices will reach $100/lb. any time prior to 2000.

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[13]One gigawatt is equal to 1,000 megawatts or roughly to the maximum power of one nuclear powerplant.

[14]DOE data indicates that less than 1 million tons of uranium ore will be sufficient to fuel the nuclear powerplants through the year 2000.

CHAPTER 3

POTENTIAL FOR THE BARNWELL PLANT TO BE OPERATIONAL

On October 8, 1981, President Reagan lifted the indefinite deferral on commercial reprocessing and indicated that the private sector should take the lead in developing commercial reprocessing services. The private sector, however, has shown little interest in either starting a new reprocessing venture or completing the Barnwell plant.

We believe that the lack of interest of the private sector to begin another reprocessing venture is, in part, due to the uncertain future of nuclear power. In addition, industry representatives we contacted believe the federal government would have to address three issues before they would seriously consider any commercial reprocessing venture, including Barnwell. These issues are:

--To what extent, if any, will the federal government permit the use of plutonium recovered during commercial reprocessing as an energy source?

--What solidified high-level radioactive waste form will the federal government accept?

--Is the federal government willing to protect a future commercial reprocessing venture from losses stemming from changes in government policy?

Addressing these issues, however, is not necessarily sufficient to encourage private industry to reenter the reprocessing business. It would only enable industry to analyze the current and future prospects for commercial reprocessing with a higher degree of certainty. Our review also disclosed a number of other issues which can affect private industry decisions in regard to reprocessing. These include licensing, state relations, and some international issues.

PERSPECTIVE ON THE FUTURE OF NUCLEAR POWER AND COMMERCIAL REPROCESSING

Commercial reprocessing has always been tied to the need to extend and/or fully utilize domestic uranium reserves. In the late 1960's and early 1970's the nuclear industry was growing rapidly. From 1966 through 1972 construction started on 61 nuclear powerplants which became operational. The government, at that time, not only expected the growth to continue but also to increase. For example, in 1972, AEC projected that anywhere from 885 to 1,500 gigawatts of nuclear power would be deployed by the year 2000. Under such a scenario, it was apparent from government

data that domestic uranium supplies probably could not meet the fuel needs of the nuclear industry through the year 2000. As a result, the government viewed development of a commercial reprocessing industry as an urgent need, and private industry viewed it as a potentially lucrative business venture.

During the next 10 years, the outlook for nuclear power changed. This lessened the urgency attached to commercial reprocessing as well as its economic prospect. Since 1975, over 80 domestic nuclear powerplant projects have been canceled and still others stretched out for several years. In December 1980, we reported that utilities were cancelling and/or delaying completion of both nuclear and other types of electric-generating plants primarily because of lower projected increases in electricity demand, financial difficulties, and to a lesser extent, regulatory problems at both the federal and state levels.[1] These problems, we found, were particularly having an impact on nuclear powerplants because of large capital investments required to construct the plants. The overall effect was a dramatic drop in the anticipated deployments of nuclear powerplants. In 1982, DOE estimated that 145 to 185 gigawatts of nuclear power would be deployed by the year 2000--less than 15 percent of AEC's estimate made 10 years earlier. In 1983 DOE projected that only 132 gigawatts of nuclear power would likely be deployed by the year 2000. Because nuclear power did not develop as projected, it is no longer expected that uranium resources will become scarce prior to 2000. We have previously reported[2] that, based on DOE's long range estimates of nuclear power utilization and domestic uranium resources, there appears to be sufficient domestic uranium to fuel the nuclear industry well past 2020.

As the importance and/or urgency to extend uranium supplies diminished, other concerns associated with reprocessing, in particular proliferation of nuclear weapons, became more significant to decisionmakers. For example, President Carter, while indefinitely deferring commercial reprocessing, also believed that a viable and economic nuclear power program could be sustained in the U.S. without reprocessing. This belief was predicated on data showing that domestic uranium supplies could meet the fuel requirements of the nuclear industry past the year 2000. Hence, he believed it was not imperative that the U.S. move ahead with reprocessing.

Although nuclear power's growth has not been as great as originally envisioned, it has nevertheless become an important

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[1]Electric Powerplant Cancellations and Delays (EMD-81-25, Dec. 8, 1980).

[2]The Liquid Metal Fast Breeder Reactor--Options For Deciding Future Pace and Directions (GAO/EMD-82-79, July 12, 1982).

use. Prior to any decision, the NRC would have to finish the GESMO proceedings (deliberations to determine whether plutonium can be used as a fuel on a widespread basis) or start another proceeding that would address the issues GESMO was evaluating. (See page 3.) NRC officials told us they have no plans for finishing GESMO at this time since there has been no request or industry initiative showing a demonstrated need for them to do so. They added even if the GESMO proceedings were reopened, much of the work would need to be redone. They estimate it could take about 3 years to complete. Finally, they told us that even if GESMO was completed, it is not certain under what conditions, if at all, plutonium would be allowed to be used as a fuel. Hence, it is difficult to predict when, if ever, and under what conditions the NRC would allow plutonium to be used as a nuclear fuel in conventional nuclear reactors.

Plutonium could also be used in the federal breeder program or stored for future use. If plutonium is used for the federal breeder program, DOE would be responsible for procuring it. However, this option is only a partial solution to the plutonium utilization question, because a fully operational Barnwell plant would produce far more plutonium than the federal government requires for its breeder program. Storing plutonium for future use is the remaining option. Utilities we contacted told us that they have no desire to store plutonium, especially if its eventual possible use is not known. This could lead to a situation in which utilities may be paying for storing plutonium that might not have any value or where the accumulated storage cost could exceed its eventual value. In this regard, some utilities' representatives expressed the concern that any plutonium recovered in reprocessing may actually turn out to be a liability for utilities in that they would be responsible for safeguarding and storing it.

WHAT SOLIDIFIED HIGH-LEVEL RADIOACTIVE WASTE FORM WILL THE FEDERAL GOVERNMENT ACCEPT?

One of the long standing issues surrounding the use of nuclear power has been the need for a permanent solution to the high-level radioactive waste problem. Both the federal government and the nuclear industry recognize that high-level radioactive waste either contained in the spent fuel or separated as a liquid cannot be allowed to accumulate without some means to ensure that it is permanently isolated from the environment.

The Nuclear Waste Policy Act of 1982, Pub. L. 97-425 (1983), is an important step in finding a solution to the problem. The act provides a comprehensive framework for disposing of spent nuclear fuel and/or high-level radioactive waste of domestic origin generated by civilian nuclear power reactors. In general, the act establishes procedures and time frames for selecting and developing repositories for spent fuel and high-level radioactive waste, authorizes the establishment of such repositories, provides a mechanism for financing disposal costs and sets forth various

other provisions related to nuclear waste disposal. One thing the act does not do--which is important in making a decision on commercial reprocessing--is specify a solidified waste form acceptable for high-level radioactive waste disposal.

Liquid high-level radioactive wastes are created during reprocessing. Although only about 4 percent of the spent fuel becomes waste, large amounts of liquid waste can eventually accumulate.[3] These wastes are extremely toxic and long-lived. The federal government since 1971 has required that liquid high-level radioactive waste generated in commercial reprocessing be solidified within 5 years after it is generated. The federal government, however, has not specified what solidified form would be acceptable for final disposal. This situation became a dilemma for the nuclear industry interested in reprocessing. According to nuclear industry officials, a commercial reprocessing venture would have to solidify the high-level radioactive waste it generates within 5 years after it began operating but would not know what solidified form the federal government would accept for final disposal. Understandably, if the solidified form selected by industry was unacceptable when the government was ready to dispose of it, it could prove to be a severe economic liability to any reprocessing venture. For example, industry could be required to repackage the waste form to meet government criteria, once that criteria became known.

Allied-General officials told us that, during the 1970's when they were attempting to obtain an operating license, they had numerous discussions with AEC and then the Energy Research and Development Administration[4] concerning the appropriate solidified waste form to be used in commercial reprocessing. According to Allied-General, although government officials indicated that borosilicate glass appeared to be the best material in which to immobilize and contain the liquid high-level radioactive waste,[5] they would not agree to take title to the waste in that form. The government also continued to do research on various other ways of

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[3]There are already hundreds of thousands of cubic meters of liquid high-level waste stored from defense reprocessing activities.

[4]Prior to the creation of DOE, the Energy Research and Development Administration had responsibility for researching and developing an acceptable solidified waste form.

[5]The process involves mixing the solidified (powdered) waste with melted glass, then pouring it into a container, and letting it cool into a solid form.

solidifying high-level radioactive waste which increased speculation within the nuclear industry that borosilicate glass might not be the eventual medium for final disposal of such wastes.[6]

Under the Nuclear Waste Policy Act of 1982, DOE is responsible for accepting high-level waste from the commercial sector for final disposal. DOE, however, has not specified any acceptance criteria. According to the Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Radioactive Waste, that DOE has signed with utilities, the acceptance criteria and general specifications for accepting liquid high-level radioactive waste will be issued no later than the date on which DOE submits its license application to the NRC for the first disposal facility. DOE expect this to be in 1991. NRC would then evaluate the appropriateness of the solidified waste form and its packaging in a repository during the licensing proceeding for the first waste repository. According to NRC, this could take a couple of years. Thus, it appears that a definitive answer to what solidified waste form would be acceptable could be many years away. To private industry decisionmakers, this leaves open an important question in assessing the business prospects of the Barnwell plant and reprocessing in general.

IS THE FEDERAL GOVERNMENT WILLING TO PROTECT A FUTURE COMMERCIAL REPROCESSING VENTURE FROM LOSSES STEMMING FROM CHANGES IN GOVERNMENT POLICY?

Many nuclear industry representatives believe that the government initially encouraged private industry to enter the reprocessing business during the late 1960's and early 1970's, but prohibited them from continuing in the business in the mid-1970's as a result of its nonproliferation policies. In the future, these representatives believe, some type of guarantee from the federal government will be necessary to protect industry's investment in a reprocessing plant against future changes in government policy.

In the mid-1970's, concerns that the recovery and use of plutonium could possibly lead to the proliferation of nuclear weapons resulted in indefinitely deferring commercial reprocessing in this country in 1977. Nuclear industry representatives whom we contacted viewed this as a reversal in longstanding government policy which ended any commercial prospects for reprocessing. Many nuclear industry representatives expressed concern that the federal government could again seriously affect future commercial reprocessing ventures. Therefore, they believe the federal

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[6]In 1983, DOE did select borosilicate glass as the waste form for solidifying high-level liquid waste at the government-owned Savannah River Plant.

government must offer some type of guarantee so that their investment, which would be substantial, is protected. A number of ways the government could provide such protection have been suggested. These include special legislation creating a mixed private/government reprocessing enterprise. Other nuclear industry representatives believed that the government guarantee could be more indirect--in the form of contractual arrangements. Such arrangements, theoretically, could be set up to include purchases of plutonium whereby, if the contractor could not supply the plutonium to the government because of changes in government policy, the federal government would pay a penalty to reimburse the business for its lost investment. While we did not evaluate the pros and cons of such guarantees or arrangements, they appear to move reprocessing at Barnwell beyond a strictly commercial venture.

In any event, many potential investors within the nuclear industry believe that the federal government, either directly or indirectly, would have to provide some type of guarantee against possible financial losses stemming from future changes in government policies towards commercial reprocessing. Such guarantees can also influence the economics of reprocessing as a private venture. For example, government guarantees could lower the risk associated with reprocessing and thereby possibly lower interest rates for borrowing funds to complete the Barnwell plant or build another plant. Thus, as with the other major unresolved issues associated with reprocessing, guarantees influence not only industry's interest in reprocessing but also, to a certain extent, the cost of reprocessing services.

OTHER ISSUES AFFECTING THE POTENTIAL OF THE BARNWELL PLANT TO BE OPERATIONAL

In the course of our review, nuclear industry and utility representatives cited other issues and/or concerns that could affect potential investor interest in reactivating the Barnwell plant. These include licensing, state relations, and international issues. In general, they did not view these issues and/or concerns as insurmountable in getting Barnwell operational. Nevertheless, they are important in facilitating private industry's interest in reprocessing and could affect any future reprocessing ventures.

Licensing

The Barnwell plant would have to obtain an NRC operating license under the same regulations which govern the licensing of nuclear powerplants. A number of utilities and nuclear industry representatives believe the current licensing process is unpredictable and potentially costly. They also believe that the unpredictability and potential costliness are even more of a concern with a reprocessing plant than nuclear powerplants because

NRC has never licensed a reprocessing plant to operate.[7] While these representatives believe that the Barnwell plant could eventually be licensed to operate, they are concerned that NRC might require costly changes to the plant as a result of licensing proceedings. The proceedings themselves could be extremely long and add further cost to getting a reprocessing plant operational.

While NRC officials are not aware of any fundamental problems with the existing facilities, they recognize the plant's uniqueness. For example, while no thermal nuclear reaction takes place at a reprocessing plant, it would handle and process large quantities of spent fuel, high-level liquid waste, and plutonium. The safety aspects and practices of such handling and processing would have to be closely examined. Also, safeguard systems for monitoring and accounting for plutonium would be closely examined. Finally, these NRC officials believe the proposed issuance of an operating license by the NRC would likely be contested. These factors could lengthen the review process and deter potential investors.

State relations

South Carolina, the state in which the Barnwell plant is located, has a long and varied history with nuclear power. Not only does the state have nuclear powerplants, but also the government's Savannah River Plant, which is located near Aiken, South Carolina. This plant has generated substantial amounts of high-level radioactive waste resulting from national defense program activities. These wastes are still stored in the state. The state also has a low-level radioactive waste burial site located near Barnwell. Over the years the state has taken an active role in controlling the amount of radioactive material entering its boundaries. For example, since 1979 the state has opposed the proposed use of the Barnwell plant as a spent fuel storage site. It has also placed limits on the amount of low-level waste entering the state. In 1983, it passed a law prohibiting, in the state, the acceptance by a commercial firm of spent fuel from a foreign country (except spent fuel or radioactive waste funded by the federal government).

Undoubtedly, South Carolina will play a key role concerning the future of reprocessing at Barnwell. While the current Governor is not opposed to reprocessing in principal, if it can be shown to be safe, he has stated he is opposed to the start up of Barnwell until "demonstrated progress" on a permanent solution to high-level radioactive waste is made. According to a speech by the Governor in September 1982, this would include demonstrating that milestones in law can be met, that there is a consistent commitment to funding a repository, and that elected officials at

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[7]The AEC, however, did license the West Valley reprocessing plant in 1966. Government reprocessing plants are not licensed.

the state level are effectively involved in decisions. The energy advisor to the Governor told us that he believes the Nuclear Waste Policy Act of 1982 is an important step in the right direction, but much depends on how it is implemented. In regard to the Barnwell plant, he believes at least three concerns must be addressed. First, the plant must be shown it can safely operate. Second, a solidified waste form should be specified for high-level radioactive waste which would be generated at Barnwell. Finally, there must be some type of guarantee to protect the state against the possibility of the owners leaving the business while high-level liquid wastes are still in the storage tanks. Finally, he told us the owners and operators of the Barnwell plant must work closely with state officials to address the aforementioned concerns.

International issues

International issues can also affect reprocessing and the possible operation of Barnwell. Our review disclosed two such issues, both of which can be politically sensitive: the nuclear proliferation issue and the issue of reprocessing foreign nuclear spent fuel in the United States.

In 1977, when President Carter announced his deferral on commercial reprocessing, the primary reason for his actions was apparently his concern that plutonium produced in reprocessing could be used by other technologically advanced countries to produce nuclear explosives. At that time the United States was attempting to discourage other countries from developing reprocessing capabilities by refraining from commercial reprocessing and by not providing reprocessing-related technical assistance to other countries.

Many advocates of reprocessing within the nuclear industry, however, believe that this action had little influence on other countries' decisions to reprocess. They point out that some countries are currently reprocessing spent fuel or are considering it (see appendix II for a synopsis of reprocessing in the free world), and told us that this country's decision not to reprocess has limited our influence in assuring that improved safeguard measures are used to monitor the production and use of plutonium. In this regard, although the United States has reportedly developed advanced safeguard systems, it has not demonstrated such systems in an operating reprocessing plant. These advocates believe that an operational reprocessing plant incorporating the latest safeguards systems available will enhance our national objective of limiting the spread of nuclear weapons.

Opponents of reprocessing, on the other hand, believe that if this country reprocesses commercial spent fuel, countries with nuclear powerplants--about 30--could perceive reprocessing as a necessary and acceptable part of the nuclear fuel cycle. These

countries may then move ahead with reprocessing and, thus, have access to plutonium and possibly nuclear weapons. These opponents claim that any safeguard system could be circumvented by a country operating a reprocessing plant.

Another potential international issue is whether reprocessing of foreign spent fuel should be allowed in the U.S. While there are no commercial reprocessing plants in operation in this country, other countries do have reprocessing plants. According to nuclear industry officials the price charged overseas for reprocessing services ranges from about $600 to $1,100 per kg of spent fuel. Allied-General representatives believe a fully operational Barnwell plant could be competitive with these prices--possibly less than half of what is currently being charged.

While nuclear industry officials believe that an operational Barnwell plant could possibly pick up a portion of the foreign reprocessing market, they recognize that reprocessing foreign spent fuel might be difficult from a political perspective. For example, the state of South Carolina in early 1983 passed a law prohibiting private firms from accepting foreign spent fuel into the state. More importantly, others have expressed concern that the nation should not assist other countries in separating plutonium from spent fuel under any conditions because such action could be counterproductive to this nation's nonproliferation objectives. As a result, nuclear industry officials believe that, at least initially, the Barnwell plant--if it becomes operational--would only reprocess domestic spent fuel.

CHAPTER 4

OBSERVATIONS

For many years commercial reprocessing has been surrounded by controversy. To a large extent the controversy stems from different views on a wide range of international, environmental, technical, and economic issues. Amid differing viewpoints, it is always difficult to develop any consensus. Moreover, over the years the views can be expected to change somewhat in light of future international and domestic policies. Nevertheless, we believe three overall observations are worth noting from the information presented in this report.

--The potential for commercial reprocessing to develop in the U.S. is driven by economics in the private marketplace which is closely tied to the future role that nuclear power will have as a domestic energy source.

--Before private industry seriously considers starting another commercial reprocessing venture, nuclear industry representatives believe three key issues associated with commercial reprocessing must be addressed by the federal government.

--Although technical assessments of plant and our discussions with knowledgeable persons disclosed no apparent fundamental problems that currently prohibit the Barnwell Nuclear Fuel Plant from operating when completed, a number of technical concerns and licensing issues need to be resolved before the plant could operate as a commercial venture. In addition, the economics for the plant as a commercial venture are not promising.

Our first observation ties commercial reprocessing to the future of nuclear power as a domestic energy source. This perspective is important to decisionmakers to adequately weigh the possible benefits and drawbacks of commercial reprocessing. At one time, the anticiated use of nuclear power was envisioned to quickly deplete our domestic uranium ore supply. Accordingly, because it offered the benefit of extending domestic uranium supplies as they became scarce, commercial reprocessing was viewed to be both in the national interest and a potentially lucrative business. Over the years, however, the anticipated growth of nuclear power in the United States has dropped dramatically. This has lessened the need once associated with reprocessing and also raised questions concerning the economic outlook for reprocessing as a business. As the need once associated with reprocessing lessened, other concerns, such as the possible proliferation of nuclear weapons, increased in importance to decisionmakers. In this regard, in the late 1970's many government officials believed that the potential drawbacks to reprocessing outweigned the benefits.

It is extremely difficult to quantify and predict, with any degree of precision, if or when the need for commercial reprocessing will make it a clearly economical business venture and outweigh potential drawbacks. If the role of nuclear power is limited and nuclear power will eventually be phased out prior to depleting uranium ore supplies, then commercial reprocessing does not appear to have a role in the nuclear fuel cycle. On the other hand, if one expects nuclear power to be a major long-term energy source either at a relatively constant level or at some rate of growth, then commercial reprocessing cannot be ruled out. At this time, the uncertainty of the future role of nuclear power makes the future of commercial reprocessing similarly uncertain.

Our second observation relates to private industry's role in starting another commercial reprocessing venture. When President Reagan announced his policy on commercial reprocessing, he stated that it was important that the private sector take the lead in developing commercial reprocessing services. This action appears to make reprocessing the prerogative of private industry, taking into account only the factors which affect normal business decisions such as economics, raising capital, and establishing a market for services. According to utilities and nuclear industry representatives, however, three unresolved issues discourage private industry from starting another commercial reprocessing venture. All of these issues transcend normal variables typically associated with business decisions. They are (1) a determination of whether and to what extent plutonium can be used on a widespread basis as nuclear fuel, (2) the identification of a waste form for solidifying high-level radioactive waste, and (3) what guarantees, if any, the government would provide to protect the industry from changes in future government policy. According to private industry and utilities representatives, resolution of these issues by the government is a necessary precondition to any private industry consideration of reprocessing as a commercial venture.

Our last observation addresses the Barnwell Nuclear Fuel Plant. While we cannot predict that the Barnwell plant can be licensed and successfully operated, technical assessments of the plant and our discussions with knowledgeable persons within and outside the government disclosed no apparent fundamental construction, technical, or licensing problems that would prohibit its eventual operation. Nevertheless, the plant represents a risk to any potential investors. Substantial amounts of money would be needed to complete the complex--over $700 million according to Allied-General. This would include modifying the plant. The extent to which proposed modifications alleviate all identified technical concerns will not be known until the plant is checked out for actual operation. In addition, the licensing proceeding for the plant could take years and possibly result in additional modifications to the plant. Finally, the economic prospect for the plant to operate as a commercial venture is not promising.

APPENDIX I

COMMERCIAL REPROCESSING

VENTURES IN THE U.S.

Venture	History
Nuclear Fuel Services Plant at West Valley, New York	Plant completed in February 1966 and granted an operating license by AEC the following April. The plant operated until 1972 when it closed to be enlarged and modified to meet federal regulations. In 1976 Nuclear Fuel Services announced it would leave the reprocessing business because compliance with federal regulations would make the venture uneconomical.
The General Electric Company's plant at Morris, Illinois	In 1967, the General Electric Company obtained a construction permit from AEC to build a reprocessing plant. This plant was scheduled for operation in 1971. However, technical problems precluded the plant from operating. The plant is now used as a spent fuel storage facility.
Allied-General's plant at Barnwell, South Carolina	In 1970 a construction permit was issued to Allied-General by AEC. In 1973, with two facilities nearly complete, Allied-General applied for an operating license. Hearings on the operating license continued intermittently until January 1976. After President Carter announced an indefinite ban on reprocessing, the NRC terminated licensing proceedings. Over the last 5 years federally sponsored research has been carried out at the plant. The plant closed down December 1983.
Exxon Nuclear Company	In 1971, Exxon Nuclear Company began research and development which eventually resulted in the company designing a large-scale reprocessing plant. However, construction of the plant was never started.

APPENDIX II

SYNOPSIS OF REPROCESSING

OUTSIDE THE U.S.

Country	Facility	Present capacity[a]	Planned capacity[a]	Comment
Belgium	Eurochemic	60	60-300	60 ton/yr facility closed in 1974. Future startup with expansion being considered.
France	La/Hague/UP2	400	800	Expansion program near completion.
	La/Hague/UP3	--	800	Under construction. Completion scheduled for 1985.
India	Tarapur	100	100	Operational.
	Kalpakkam	--	100	Under construction for late 1980's.
Italy	Eurex	5-10	10	Operational pilot plant.
Japan	Tokai	210	210	Operational.
	no site yet	--	1,200	Planned 1990.
United Kingdom	Windscale	400	400	Operational.
	Throp	--	1,200	Under construction. Completion schedued late 1980's.
W. Germany	Karlsruhe	35	35	Operational.
	Hesse	--	350	Commercial interest. No specific site or date yet.

[a]Capacities in metric tons of fuel per year.

Source: Congressional Research Service Issue Brief entitled Nuclear Energy: Enrichment And Reprocessing Of Nuclear Fuels, dated May 28, 1982.

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