REPORT BY THE

Comptroller General

OF THE UNITED STATES

Issues Concerning The Department Of Energy's Justification For Building The Gas Centrifuge Enrichment Plant

The Department of Energy is building a gas centrifuge uranium enrichment plant at Portsmouth, Ohio. By the end of this fiscal year, the Department will have spent about $1.2 billion on the project. The Department expects to complete the project by 1994 at a total cost of about $7 billion (fiscal year 1983 dollars).

GAO's evaluation raises a number of questions about the Department's justification. Congress should consider the information developed in this report, along with other considerations, in making future funding decisions on the centrifuge plant. In addition, GAO points out that the Congress should view a decision to build the increment of the plant now under construction as a commitment to build the entire plant.

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MAY 25, 1982

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

B-207463

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

Dear Mr. Chairman:

As requested in your letters of August 24, 1981, and March 19, 1982, this report discusses our evaluation of the Department of Energy's justification for building the Portsmouth, Ohio, gas centrifuge enrichment plant.

At your request, in order to provide this report in time for use during the appropriation process, we did not obtain the Department's comments on this report. We are also sending copies of this report today to the Chairman, Subcommittee on Energy and Water Development, House Committee on Appropriations; the Director, Office of Management and Budget; and the Secretary of Energy.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 2 days from the date of the report. At that time, we will send copies to other interested committees and members of the Congress, and copies will be made available to others upon request.

Because of the expressed concern of several members of Congress, we plan to ask the Department of Energy to provide us its comments on the report. The comments will be carefully evaluated and, as appropriate, supplemental information furnished to the Congress.

Sincerely yours,

Charles A. Bowsher

Comptroller General
of the United States

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

ISSUES CONCERNING THE DEPARTMENT OF ENERGY'S JUSTIFICATION FOR BUILDING THE GAS CENTRIFUGE ENRICHMENT PLANT

D I G E S T

The Department of Energy (DOE) is building a gas centrifuge uranium enrichment plant at Portsmouth, Ohio. By the end of this fiscal year, DOE will have spent about $1.2 billion on the project. DOE expects to complete it in 1994 at a total cost of $7 billion (fiscal year 1983 dollars).

At present, DOE enriches uranium for its domestic and foreign customers at three enrichment plants. These plants use a dependable but electric power-intensive technology known as gaseous diffusion. Although the three plants were built in the 1940s and 1950s, DOE is nearing completion of a 10-year, $1.5 billion program to improve their efficiency and increase their commercial production capacity by about 60 percent. When completed, the plants will be able to provide the enrichment services required for nuclear power reactors to produce up to 240 gigawatts-electric 1/-- or about 240 nuclear power plants--plus expected Government requirements.

DOE has also developed a more energy efficient technology, called gas centrifuge, which can be built in increments to better match supply with demand and which DOE plans to use in the enrichment plant now under construction. Because it is more energy efficient, the operating costs of a centrifuge plant are expected to be much less than operating costs of gaseous diffusion plants. Conversely, capital and maintenance costs are expected to be higher. Nevertheless, when the plant is completed in 1994, DOE expects that it will provide enrichment

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1/A gigawatt-electric is one million kilowatts of electricity. Most modern nuclear power plants are capable of producing about one gigawatt of electricity.

services at less cost than the gaseous diffusion plants. Therefore, at that time DOE plans to cut back on its gaseous diffusion plant operations.

In addition, DOE is in the early stage of developing an advanced isotope separation enrichment technology. If successful, DOE believes it can reduce the costs of enriching uranium substantially below the costs of either of the other two enrichment technologies. Although there are still some uncertainties--the technology has never been commercially demonstrated--DOE believes this new technology could be developed and a production facility could be available as early as the mid-1990s.

When the Congress authorized construction of additional enrichment capacity in 1975, demand for U.S. enrichment services was expected to exceed the increased capacity of the improved gaseous diffusion plants by the early 1980s. This demand never materialized, however, because of two events. First, beginning in the mid-1970s, numerous nuclear power plants were canceled and deferred in the United States and elsewhere. Second, new foreign enrichment services suppliers emerged and obtained major shares of the foreign enrichment services market. Thus, since 1975 the United States has changed from a near monopoly supplier of enrichment services to an expanding nuclear power industry, to one of several suppliers to an industry with diminished growth expectations.

In a November 1980 report GAO noted these changed circumstances and recommended that the Congress consider not appropriating additional funds for construction of uncommitted increments of the gas centrifuge capacity until DOE developed and presented sufficient documentation to demonstrate that the additional capacity was needed to meet demand, to further U.S. non-proliferation objectives, or was justified on an economic basis. 1/ At

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1/"Evaluation of Selected Features of U.S. Nuclear Non-Proliferation Law and Policy," EMD-81-9, Nov. 18, 1980.

about the same time, DOE began to justify the gas centrifuge plant on the basis of long-range economic, nuclear non-proliferation, and balance-of-trade benefits in addition to meeting expected demand.

At the request of the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, GAO evaluated DOE's current justification for building the new gas centrifuge enrichment plant by answering three basic questions:

--Is the new plant needed to satisfy projected demand for DOE enrichment services? GAO concluded it is not. DOE currently forecasts that it will be supplying enrichment services for 266 gigawatts of electricity by the year 2000, whereas GAO believes a more realistic estimate is between 184 and 217 gigawatts. At 217 gigawatts, DOE's existing enrichment capacity is sufficient through the year 2000 and beyond. (See p. 10.)

--Will the new plant enable DOE to substantially reduce the long-range costs--and therefore the prices--of its enrichment services? DOE believes it will but GAO is unconvinced. The disagreement centers around the projected demand for enrichment services and the availability and economics of an advanced isotope separation facility. DOE's economic justification for building the gas centrifuge plant is based on an October 1980 "Uranium Enrichment Strategy Study." The different options presented in the study generally show that building the gas centrifuge plant is economical at a high demand of 350 gigawatts or if DOE is unable to develop an advanced isotope separation technology. It is not economical at a lower demand of 250 gigawatts in the year 2000, and is even less economical at the lower demand levels estimated by GAO, if DOE successfully develops this advanced technology. (See pp. 15 and 17.)

GAO points out, however, that the relative cost differences between building and not building the centrifuge plant--in both DOE's and GAO's analysis--may not be significant when one considers that these economic analyses depend on projections of costs and other assumptions 31 years into the future.

For example, using GAO's expected demand of 217 gigawatts in the year 2000, the present value cost of providing enrichment services over a 31-year period is about $59.5 billion if the gas centrifuge facility is built and $58.7 billion if it is not built, or $800 million less--a 1.3 percent difference. Such a relatively small difference in cost over such a long period may not be significant when deciding which option is the most economical and thus must be viewed with caution. Adding to this uncertainty are some technical problems GAO found in the computerized model used by DOE to develop its economic justification. (See pp. 16 and 23.)

--Is the new plant likely to improve DOE's competitive position in the world enrichment services marketplace? Even if the new plant offered long-range cost (and price) reductions, it is unlikely that DOE's competitive position would improve. Potential foreign enrichment services customers are as interested in other factors, such as assurance of supply and being subject to U.S. nuclear nonproliferation policies, as they are in price. Furthermore, a number of foreign countries are either partners in existing enrichment services operations or are interested in developing their own enrichment capabilities. (See p. 21.)

Constructing the gas centrifuge plant on the current schedule is clearly economical under a scenario of high demand for enrichment services or failure of the advanced isotope separation technology. The current trend, however, points to even further deterioration in nuclear power growth expectations. Furthermore, DOE currently expects to successfully develop the advanced isotope separation technology.

GAO recognizes that sudden events could cause a sharp reversal in the outlook for nuclear power. If this should happen, new enrichment capacity can be brought on line faster than new nuclear power plants. For example, it currently takes 12 to 14 years to bring a nuclear power plant on line, whereas a new enrichment facility takes about 10 years.

In the long run, DOE's enrichment services customers--primarily domestic and foreign

utilities--will pay for construction of the gas centrifuge plant. Short-run budgetary impacts, however, are significant, particularly in a period of increasing pressure to reduce the Federal budget. The budgetary options, expressed in fiscal year 1983 dollars, include:

--Continue the project on schedule. This would require an additional $5.5 billion in appropriations through fiscal year 1994.

--Terminate the project immediately. This would reduce the need for appropriations by about $5.1 billion through 1994.

--Slow the project one or more years. This would reduce appropriation needs in early years, but would add to overall costs.

--Complete only the portion now under construction. This would require an additional $2.2 billion in appropriations. (See p. 27.)

While offering budgetary savings, the option to complete only the part now under construction would increase rather than decrease the cost of DOE enrichment services. According to DOE, the cost of enriching uranium in this scaled-down plant would be about three times as expensive as enriching uranium in the existing enrichment plants and in the entire gas centrifuge plant. This is because completing only the portion now under construction will cost about $3.7 billion--a little more than one-half the cost of the entire gas centrifuge plant--but will produce only up to one-sixth of the amount of enriched uranium. The relatively high capital cost of the scaled-down plant is due to the need to complete the many centrifuge machine process building support facilities which were designed to support eight rather than two process buildings. Therefore, strictly from an enrichment services cost standpoint, it would be better to build the entire plant than only the portion now under construction. (See p. 29.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

GAO's work shows that building the centrifuge plant is not justified at current expected

demand levels. On the other hand, constructing the plant is economical if events cause a sudden increase in the demand for nuclear power or if DOE's efforts to develop advanced isotope separation technology fails. If either of the events occur, however, DOE has sufficient time to build new capacity.

Further, it seems clear that completing only the part of the plant currently under construction offers no economic advantages.

There are other considerations the Congress should weigh in addition to the information presented in this report. These considerations revolve around judgments about the future growth of nuclear power; the perceived importance of early replacement of the gaseous diffusion plants with the more energy efficient gas centrifuge technology; the social impacts of terminating the plant; and the advantages or disadvantages to the Tennessee Valley Authority, DOE's principal electric power supplier, of DOE using additional power for the gaseous diffusion plants if the centrifuge plant is not built.

The Congress should consider the information presented in this report along with information on these and other relevant factors in making future funding decisions on the centrifuge plant. In addition, because of the economic disadvantages of only completing the first portion of the plant, GAO believes that the Congress should view a decision to build the first increment of centrifuge production as a commitment to build the entire plant.

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At the request of the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, in order to provide this report in time for use during the appropriation process, GAO did not obtain DOE's comments on this report. Because of the expressed concern of several members of Congress, GAO plans to ask DOE to provide GAO its comments on the report. The comments will be carefully evaluated and, as appropriate, supplemental information furnished to the Congress.

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
DOE	Department of Energy
ERDA	Energy Research and Development Administration
GAO	General Accounting Office
NRC	Nuclear Regulatory Commission
TVA	Tennessee Valley Authority

CHAPTER 1

INTRODUCTION

Uranium enrichment is a process which prepares uranium for use as a nuclear reactor fuel by converting natural uranium into a mixture richer in the fissionable isotope uranium-235. Since 1969, the Federal Government--through the former Atomic Energy Commission (AEC), the former Energy Research and Development Administration (ERDA), and now the Department of Energy (DOE) 1/--has been enriching uranium owned by domestic and foreign utilities. Today, 72 nuclear power plants in the United States and many more throughout the world are fueled with uranium enriched by DOE.

DOE's existing uranium enrichment capability consists of three plants located at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. These plants were built in the 1940s and 1950s to satisfy U.S. military requirements for highly enriched uranium; however, since the 1960s the plants have been primarily used to provide enrichment services for domestic and foreign nuclear power plants. In addition to these plants, DOE is now building another enrichment plant at Portsmouth, Ohio.

The existing uranium enrichment plants use a process known as gaseous diffusion. DOE is finishing a 10-year, $1.5 billion program to improve the efficiency and expand the capacity of the three gaseous diffusion plants. When completed in fiscal year 1983, the production capacity of the three plants will have been expanded from 17 to 27 million separative work units 2/--a capacity increase of about 60 percent. At that time, the plants will be able to provide the enrichment services required for nuclear power reactors to produce up to 240 gigawatts-electric 3/--or about 240 nuclear power plants--plus expected government requirements of about 2 million separative work units

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1/AEC was abolished on January 19, 1975, and its uranium enrichment activities were transferred to ERDA. On October 1, 1977, ERDA was abolished and its enrichment activities were transferred to DOE.

2/The production capacity of enrichment plants is defined in terms of Separative Work Units. It is a measure of the amount of effort expended to separate a given amount of natural uranium into two components--one having a higher concentration and one having a lower concentration of fissionable uranium-235.

3/A gigawatt-electric is one million kilowatts of electricity. Most modern nuclear power plants are capable of producing about one gigawatt of electricity.

per year over the long run. In fiscal year 1981, DOE operated the plants at about 40 percent of their capacity and supplied enriched uranium for 92 gigawatts of commercial power plus government requirements.

Although the gaseous diffusion plants use a proven technology, they also require large amounts of electricity. For this reason, for a number of years DOE and its predecessors have been researching and developing other uranium enrichment technologies. DOE is through the demonstration stage on one such technology--gas centrifuge--and plans to use this technology in the $7 billion enrichment plant it is now building at Portsmouth, Ohio. DOE plans to continue development work on the gas centrifuge technology to further improve its efficiency.

With gas centrifuge technology, uranium is enriched in its content of fissionable isotopes by spinning uranium in a series of centrifuge machines. Tens of thousands of these machines will be required for a new plant. The gas centrifuge process was chosen for the new plant because in comparison to the gaseous diffusion process, it uses only 5 percent of the electricity, and can be built in modular units, thus allowing capacity to be more closely matched with demand. Because the gas centrifuge technology uses much less electricity than the gaseous diffusion technology, operating costs of a gas centrifuge plant are expected to be much less than those of a gaseous diffusion plant. However, the new gas centrifuge plant is expected to have a relatively higher capital cost. Maintenance costs--primarily repair and replacement of the tens of thousands of centrifuge machines--are also expected to be much higher than gaseous diffusion plant maintenance costs.

In addition, DOE has also been developing three advanced isotope separation enrichment technologies. These technologies are based on concepts which differ from both diffusion and centrifuge. DOE has not yet completed the demonstration stage for these technologies.

JUSTIFICATION FOR USING THE GAS CENTRIFUGE TECHNOLOGY

In 1974, demand for U.S. enrichment services was so high that AEC closed its order books because all of its available enrichment capacity was firmly committed. At that time, AEC supplied all domestic enrichment services requirements and almost all enrichment services to the foreign market outside the communist world. Therefore, in December 1975, the Congress authorized construction of new enrichment capacity at Portsmouth, Ohio, to permit ERDA--AEC's successor--to reopen the enrichment services order books. At that time, ERDA expected that the demand for its enrichment services would exceed its existing capacity in the early 1980s. ERDA originally intended to use the proven gaseous diffusion technology in the new facility. On April 20, 1977, however, President Carter

announced that ERDA would use the new gas centrifuge technology instead.

The Carter Administration's decision to use the new gas centrifuge technology resulted in part from the much lower electrical power requirements and in part from downward revisions in the demand for enrichment services. The revised projections showed that enough time was available to fully develop the centrifuge technology and to design and construct a gas centrifuge plant before demand would exceed the capacity of the existing gaseous diffusion plants.

Projections of demand for U.S. enrichment services have continued to decline

DOE's forecasts of demand for its enrichment services have continued to decrease since the Carter Administration's decision to use gas centrifuge technology in the new enrichment plant. In April 1978, for example, DOE lowered its demand forecast and, because of reduced demand projections, revised its gas centrifuge plant construction plans. Instead of completing the entire plant in 1988 as originally planned, DOE decided to build only the first increment of the capacity by 1988 and to complete the plant by 1994. The scheduled completion of the first increment of the plant has now slipped to 1989 due to past budget cuts.

The following table shows how DOE and its predecessor have reduced their forecasts of demand for U.S. enrichment services since the Congress authorized construction of new enrichment capacity in 1975.

DOE Projections of Demand
For U.S. Enrichment Services

Fiscal year	Projection when Portsmouth add-on plant authorized (Dec. 1975)	Projection when decision made to build only first increment of authorized capacity by 1988 (Apr. 1978)	Projection in effect during fiscal year 1981 authorization hearings (Mar. 1980)	Most recent projection (Aug. 1981)
	(in millions of separative work units)			
1980	26.0	18.3	11.2	a/10.8
1982	40.6	28.5	16.8	15.1
1985	37.2	38.5	24.0	24.0
1988	35.1	38.8	27.2	26.8
1990	unavailable	39.6	30.3	25.0
1995	unavailable	unavailable	38.8	30.8

a/Actual.

In part these declining demand estimates have been due to the continuing cancellations and deferrals of nuclear power plants, particularly in this country. The emergence of competition from the Soviet Union and two consortia of European countries as enrichment services suppliers to other countries has also added to the decline.

DOE has expanded its justification for the gas centrifuge plant to include long-range economics

DOE presently estimates that demand for its enrichment services will exceed the capacity of its existing gaseous diffusion plants in 1993. DOE does not now, however, justify building the gas centrifuge plant strictly on the basis of its demand forecast. DOE believes it should construct the new plant--whether or not its forecasted demand materializes--because the plant will significantly reduce the long-range costs and prices of enrichment services.

The price of DOE's enrichment services is, as required by law, based on full cost recovery over a reasonable period of time. Therefore, DOE believes that by reducing the long-range costs of its enrichment services, it can enhance its competitive position in the worldwide enrichment services market. According to DOE, obtaining more foreign customers for enrichment services will promote U.S. nuclear non-proliferation objectives--the foreign customers would have to agree to U.S. non-proliferation requirements--and benefit the U.S. international trade balance.

CURRENT STATUS OF GAS CENTRIFUGE PLANT CONSTRUCTION

DOE began constructing the gas centrifuge plant in 1979. When completed, DOE expects the plant to cost about $7 billion in fiscal year 1983 dollars. Through the end of fiscal year 1982, about $1.6 billion had been authorized and about $1.5 billion appropriated for the project. By the end of fiscal year 1982, DOE estimates it will have made total expenditures of about $1.2 billion for the centrifuge facility. Most of this amount will have been used to (1) partially construct two of the planned eight gas centrifuge process buildings, (2) complete site preparation for all process buildings, (3) complete construction of several support facilities, and (4) start construction of other plant facilities.

PREVIOUS GAO POSITION AND DOE RESPONSE ON THE GAS CENTRIFUGE ENRICHMENT PLANT

As part of our evaluation of the implementation and impact of the Nuclear Non-Proliferation Act of 1978 (22 U.S.C. 3201), in November 1980, we reported to the Congress on our evaluation

of selected features of U.S. nuclear non-proliferation law and policy. 1/ In that report we concluded that, from the standpoint of ensuring the availability of U.S. enrichment service to meet foreign demand, it was not apparent that construction of additional enrichment capacity was then needed because:

--There had been a dramatic decrease in domestic and foreign demand for U.S. enrichment services since the additional capacity was authorized for construction, leaving the United States with excess capacity from its existing facilities.

--DOE planned on operating its gaseous diffusion plants in the 1980s in a manner that would produce much less enriched uranium than the plants are capable of producing.

--The prospects of the United States gaining many new foreign enrichment customers in the 1980s was generally bleak.

--Foreign concerns over contracting with the United States for enrichment services centered around U.S. nonproliferation policies and export controls, and therefore would not be alleviated by construction of the new gas centrifuge plant.

--Advanced enrichment technologies under development could make centrifuge technology obsolete in the 1990s.

In view of the changed circumstances noted above and the cost of constructing the new gas centrifuge plant, we said the Congress should look very closely at DOE requests for construction funding. In particular, we said DOE needed to develop and present sufficient documentation demonstrating that the additional capacity is needed to meet demand, to further U.S. nonproliferation objectives, or is justified on an economic basis. If convincing documentation is not presented, we said, the Congress should consider not appropriating additional funds for construction of uncommitted increments of centrifuge capacity. In commenting on our earlier report, DOE said that based on considerations of both demand and cost savings, it believed that the first increment of the gas centrifuge plant is fully justified. DOE agreed, however, that the installation of follow-on increments of capacity should be scheduled to meet market demand and should be fully justified at the time the commitment is sought.

OBJECTIVES, SCOPE, AND METHODOLOGY

On August 24, 1981, the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce,

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1/"Evaluation of Selected Features of U.S. Nuclear Non-Proliferation Law and Policy," EMD-81-9, Nov. 18, 1980.

requested our evaluation of DOE's justification for building the gas centrifuge enrichment plant. Subsequently, on March 19, 1982, the Chairman requested that we address in our report four issues which were raised during the Subcommittee's March 11, 1982, hearing on DOE's budget request. These issues are (1) the expected demand for DOE enrichment services, (2) the reliability of estimated centrifuge machine acquisition and operating costs, (3) the short- and long-term budgetary impacts of building or not building the new centrifuge enrichment plant, and (4) the validity of the computerized model DOE used to justify building the gas centrifuge plant on a long-range economic basis. Thus, our overall objective was to evaluate DOE's justification for building the gas centrifuge plant, and consistent with the larger objective, to address the questions raised by the Subcommittee Chairman. To meet our objectives, we addressed these basic questions:

--Is the new plant needed to satisfy demand for DOE enrichment services?

--Will the new plant enable DOE to substantially reduce the long-range cost of its enrichment services?

--Is the computerized model DOE used to prepare its economic analysis valid for this purpose?

--Is the new plant likely to improve DOE's competitive position in the world market?

--What are the short- and long-term budgetary impacts of building or not building the new plant?

We performed our work in accordance with GAO's "Standards for Audits of Government Organizations, Programs, Activities, and Functions."

Using documentation obtained from DOE and the Nuclear Regulatory Commission (NRC), we analyzed demand for DOE enrichment services on a plant-by-plant basis, taking into account plant cancellations, deferrals, and delays. In addition, we interviewed officials from the Tennessee Valley Authority (TVA), the largest supplier of electricity for DOE's existing enrichment plants, about the methodology it used and the results it obtained in forecasting demand for DOE enrichment services. We also sent a questionnaire, developed in accordance with GAO standards, to all 79 of DOE's domestic and 31 of its 35 foreign enrichment services customers to obtain first-hand information on their enrichment service requirements and plans. At the request of the Department of State, we did not send our questionnaire to four of DOE's foreign customers. We received replies from 62 domestic (78 percent) and 19 foreign (61 percent) customers for an overall 74 percent response rate. We used the questionnaire responses as well as our other analyses and discussions to assess DOE's latest demand forecast.

To determine if the gas centrifuge plant will enable DOE to substantially reduce long-range enrichment costs we (1) reviewed DOE economic and operating planning studies, (2) evaluated the appropriateness of the computer model DOE used as the basic tool for preparing its economic analysis, (3) determined the reasonableness of key input assumptions, and (4) tested the sensitivity of the model to changes in the values of key input assumptions.

As part of our analysis we evaluated two different DOE studies related to its uranium enrichment operations. One study, the October 1980 Uranium Enrichment Strategy Study, was done by DOE to determine the appropriate levels of continued development and deployment of enrichment technologies so as to minimize the costs of enriched uranium over long campaign periods. The other study, DOE's December 1981, Uranium Enrichment Operating Plan, had the primary objective of updating the previous enrichment operating plan. It also reexamined the validity of DOE's overall enrichment strategy, which, according to DOE, is based on the analysis reflected in the October 1980 strategy study. Based on our analysis and discussions with DOE officials, we determined that the methodology used in the October 1980 strategy study was better suited for evaluation of the long-range economics of building the centrifuge plant than was the methodology used in the operating plan. Because of this, we used the earlier strategy study methodology, updated to reflect current information, in our analysis of whether or not the gas centrifuge plant would enable DOE to substantially reduce long-range enrichment costs.

To determine if the computerized model is valid for the use DOE made of it, we attempted to verify that (1) the mathematical equations of the model are accurate and conform to physical and economic reality, and (2) the computer properly implements the mathematical equations.

With DOE's assistance, we identified the following input assumptions as the key assumptions used in DOE's economic analysis which, if changed, would cause the most significant change in the output: (1) demand for enrichment services, (2) centrifuge plant capital and operating costs, (3) electric power costs, and (4) the discount rate used to put alternative long-range economic costs on a present value basis for comparative purposes.

Our methodology for testing the reasonableness of demand for DOE enrichment services is described above. To test the reasonableness of DOE's centrifuge plant capital and operating costs, we reviewed DOE's centrifuge machine and related components developmental experience. Also, to determine the impact of potential cost overruns, we escalated DOE's cost estimates by 10 percent. With respect to electric power costs, we reviewed the basis for DOE's power cost projections, then developed our own projections based upon projections by DOE's Energy

Information Administration and a widely used economic model. 1/ Finally, we reviewed DOE's rationale for selecting the discount rate it used and calculated a rate more applicable to DOE's economic evaluation.

As discussed in more detail in chapter 3, we found a number of errors in the economic model and some serious deficiencies in documentation. While these errors and deficiencies prevented us from validating the model, their existence does not necessarily mean that the model cannot be used to compare the different costs of alternative enrichment technology strategies given assumptions on the demand for enrichment services and the costs of building and operating enrichment plants. While the model may not accurately calculate the total costs for any one enrichment technology strategy, it is useful to determine which strategy is most cost effective on a relative basis. For this reason, and because DOE's computerized model forms the basis for its economic justification for building the gas centrifuge plant on its current schedule, we used the model for the limited purpose of testing the impact of changes in key assumptions on DOE's economic justification. We did this by rerunning the model holding some inputs constant at values DOE currently uses for enrichment planning and varying others in a way we believe to be more realistic.

With respect to DOE's position that the gas centrifuge plant would enhance its competitive position in the world enrichment market, we principally relied on our earlier work in evaluating the Nuclear Non-Proliferation Act of 1978, and supplemented this with information we received from DOE's foreign customers in response to our questionnaire.

To determine the short- and long-range budgetary impacts of building or not building the gas centrifuge plant, we (1) identified DOE's funding plan for constructing the entire gas centrifuge plant on its current schedule and alternative longer schedules, (2) obtained DOE's estimate of the cost to terminate the plant, (3) obtained DOE's estimate of the cost to complete only the portion of the plant now under construction, and (4) reviewed DOE's method for recovering the costs of its enrichment services over a reasonable period of time.

The Congressional Research Service also studied the issue of the need to build the gas centrifuge plant. Its study, however, was not available until shortly before this report was issued. Our evaluation differs from the Congressional Research Service's work in its scope and methodology. For example, our evaluation addressed issues such as the adequacy of DOE's computer model, the reasonableness of projected gas centrifuge

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1/CYCLELONG 2007A model developed by Data Resources, Inc.

plant costs, and a reactor-by-reactor analysis of demand for DOE enrichment services.

Limitations on the scope of our review

The scope of our work was limited to evaluating DOE's justification for building the centrifuge plant. In this context, we did not evaluate in detail several other factors which may bear on a decision of whether to build the centrifuge plant including

--the social impacts of not building the plant--i.e., the effect of termination on private suppliers, contractors, and unemployment in the area;

--the cost of restarting the gas centrifuge plant construction project at some future time if additional enrichment capacity was needed and an advanced isotope separation enrichment technology was not available at less cost.

--the overall advantage or disadvantage to TVA, DOE's primary supplier of electric power, of operating the diffusion plants at increased levels, thereby using TVA's current and projected excess electrical power capacity.

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Chapter 2 discusses forecasted demand for DOE enrichment services. Chapter 3 discusses our evaluation of (1) DOE's long-range economic analysis including our efforts to validate the computerized model DOE used as a fundamental tool in this analysis; (2) the status of advanced isotope separation enrichment technology; and (3) DOE's position that construction of the gas centrifuge plant will enhance its competitive position in the world enrichment services market. Chapter 4 discusses the costs and budgetary impacts of building the gas centrifuge plant, building only the portion now under construction, and terminating the entire project. Finally, chapter 5 presents our overall observations, conclusions, and a matter for consideration by the Congress.

As requested, we did not obtain DOE comments on this report. Because of the expressed concern of several Members of Congress, we have asked DOE to provide its official comments. The comments will be carefully evaluated and, as appropriate, supplemental information furnished to the Congress.

CHAPTER 2

THE UNITED STATES DOES NOT NEED ADDITIONAL URANIUM ENRICHMENT CAPACITY TO MEET DEMAND

In 1974, demand for U.S. enrichment services was so high that AEC closed its order books because all of its available enrichment capacity was firmly committed and demand was expected to exceed capacity by the early 1980s. At that time, AEC supplied all domestic enrichment services requirements and almost all enrichment services to the foreign market outside the communist world. Since then there has been a steady decline in forecasts of future demand for DOE's enrichment services because of the dramatic decline in the expected growth in nuclear power and the emergence of foreign enrichment service suppliers. Currently, DOE does not expect demand to exceed its existing capacity until 1993--about 10 years later than expected in 1974. We believe DOE's current projections are still too optimistic and its existing gaseous diffusion plants are ample to meet demand through the year 2000 and beyond.

The following sections discuss

--how conditions have changed since the new enrichment plant was authorized in 1975, and

--why DOE's current demand forecast is overly optimistic.

CONDITIONS HAVE CHANGED SINCE THE NEW ENRICHMENT PLANT WAS AUTHORIZED

When the Congress authorized construction of new enrichment capacity in 1975, ERDA had committed the full capacity of the existing gaseous diffusion plants and expected that production requirements to satisfy this contractual demand would exceed the existing capacity by the early 1980s. Through the mid-1970s, over 200 nuclear power plants had been ordered in this country alone. Since then, however, 61 of these plants have been canceled, construction of others has been indefinitely deferred, and construction on still others has slipped several years. Furthermore, only six domestic plants have been ordered since 1974 and none since 1978. At present, in the United States 72 nuclear power plants are operating, 75 are under construction, and 11 more are under construction permit review by NRC. Some of the plants in the latter two categories may yet be canceled. Likewise, the nuclear power programs of other nations have generally not expanded as was once anticipated.

Also, when the new plant was authorized, ERDA had a near monopoly of the non-communist foreign uranium enrichment market. Since that time, however, new sources of uranium enrichment

services have emerged and established solid market positions among foreign customers. The result has been a decline in DOE's market share from a near monopoly to about a 35 percent share of the foreign, noncommunist country market. The foreign enrichers currently competing with DOE are:

--The Soviet Union, which has supplied enrichment services to European utilities since the early 1970s and is reportedly willing to supply the free world with 3 to 4 million separative work units per year.

--EURODIF, a consortium of the French, Spanish, Belgian, and Italian governments or utilities, which not only provides enrichment services to member countries, but also actively seeks to sell enrichment services to non-member countries. EURODIF has a 10.8 million separative work unit capacity gaseous diffusion plant.

--URENCO, a consortium of the United Kingdom, West Germany, and The Netherlands, has a current capacity of 600,000 separative work units and is reportedly committed to expanding this capacity to at least 2 million separative work units.

In addition, Japan, Australia, South Africa, and Brazil have either begun or expressed interest in developing uranium enrichment production capabilities.

DOE'S CURRENT ENRICHMENT SERVICES DEMAND FORECAST IS TOO OPTIMISTIC

DOE's current demand projections are divided into three categories--low, mid, and high. However, in planning its enrichment plant operations and in recent congressional testimony, DOE has used its mid-level forecast of 266 gigawatts by the year 2000 as the most likely amount of domestic and foreign demand for its enrichment services. This forecast exceeds the capacity of the existing gaseous diffision facilities by about 26 gigawatts. In contrast, we believe that it is more likely that demand will be between 184 and 217 gigawatts by the year 2000--well within the capacity of the three existing plants to supply 240 gigawatts of commercial nuclear power plus estimated government requirements. DOE's forecast of 266 gigawatts is too optimistic because it includes:

--10 gigawatts representing domestic nuclear power plants that have been canceled since DOE prepared its forecast.

--2 gigawatts representing domestic power plants that DOE said it will not include in future forecasts through the year 2000 because these plants have been indefinitely deferred.

--20 gigawatts which are not under contract to DOE and which represent domestic plants DOE projected will be planned, constructed, and operating between 1995 and 2000. In view of the decline in the domestic nuclear power program and the time required to bring new nuclear plants on line, we believe this portion of DOE's forecast is too uncertain to be included in a demand forecast supporting construction of new enrichment capacity.

--2 gigawatts of foreign demand for which utilities are uncertain about renewing their contracts with DOE when they expire.

--15 gigawatts not under contract representing anticipated new foreign plants for which foreign utilities indicated in response to our questionnaire that they are uncertain about contracting with DOE for enrichment services or are not planning to operate any new plants by the year 2000.

Deducting the above from DOE's current forecast reduces it to 217 gigawatts--the figure we believe is the more probable high demand for DOE enrichment services by the year 2000. Furthermore, the possibility exists that demand could be even lower. For example, still included in the 217 gigawatt high demand figure are

--4 gigawatts of foreign demand, for which DOE does not have contracts. We did not send questionnaires to these countries.

--11 gigawatts of domestic demand for which utilities responding to our questionnaire indicated that they are uncertain about renewing their contracts with DOE when they expire. This includes enrichment services for 11 nuclear power plants which will be approaching the end of their useful lives at about the time their current contracts expire.

--18 gigawatts of domestic reactor demand that the management and planning staff of NRC believes is likely to be canceled or indefinitely deferred. Some of the plants which make up this demand are under construction and others are under NRC construction permit review.

Subtracting these amounts, which total 33 gigawatts, results in a lower estimate of anticipated demand for DOE's enrichment services of 184 gigawatts.

Other organizations show lower demand forecasts

During the course of our review, we examined other information on the future demand for DOE enrichment services which tends to support our conclusion that demand will likely be lower than DOE forecasts. Specifically, we reviewed

--a TVA study completed in October 1980 that forecasts 206 gigawatts of demand for DOE enrichment services by the year 2000 in its most probable demand case, and

--a recent NRC staff memorandum which estimated that there will be about 115 gigawatts of domestic nuclear power on line by the year 2000--55 gigawatts less than DOE's projection of 170 gigawatts of domestic nuclear power demand in the year 2000.

CHAPTER 3

THE GAS CENTRIFUGE PLANT MAY NOT REDUCE ENRICHMENT COSTS OR IMPROVE DOE'S MARKET POSITION

In October 1980, DOE prepared a "Uranium Enrichment Strategy Study" in which it examined alternative mixes of enrichment technologies and their associated estimated costs over a 31-year period. The study formed the basis for DOE's economic justification. In preparing the study, DOE used a computerized model to determine long-range enrichment costs--using various enrichment technology mixes and levels of demand--and to convert the long-range costs to a present value basis for comparative purposes. By minimizing its enrichment services costs--and therefore prices--DOE expects to increase its share of the foreign enrichment market, and thereby improve the U.S. nuclear non-proliferation and balance of payments positions.

We evaluated DOE's economic justification for building the gas centrifuge plant and found that:

--Demand is by far the most critical factor affecting the economics of the gas centrifuge plant. Both DOE's study and our own analysis show that constructing the plant is not cost-effective over the long run at demand levels of 250 gigawatts and below in the year 2000.

--Building the gas centrifuge plant is not economical if DOE is successful in developing an advanced isotope separation enrichment technology by the mid-1990s. DOE believes it can meet this schedule, but there are remaining uncertainties. Thus far, for example, only the scientific feasibility of the technology has been established. If DOE is not successful in developing an advanced separation technology, building the gas centrifuge plant is economical.

--To a lessor extent, future electric power costs, gas centrifuge plant construction and operating costs, and the discount rate used to put long-range costs on a present value basis also affect the economics of constructing the gas centrifuge plant. We believe that DOE, in its economic analysis, over-estimated future electric power costs and did not consider uncertainties inherent in a first-of-a-kind facility like the gas centrifuge plant. This favored construction of the plant. On the other hand, the high discount rate DOE used in its analysis penalized the long-range economics of building the gas centrifuge plant.

--Constructing the gas centrifuge plant is unlikely to improve DOE's competitive position in the foreign enrichment market because it apparently will not reduce DOE's long-range enrichment costs and prices. Even if costs were reduced, it is still unlikely to improve DOE's position because potential foreign customers are interested in supply assurances and other factors in addition to price.

Furthermore, we also found technical problems and a lack of written documentation in DOE's computerized model which precluded us from validating DOE's economic analysis. Despite these concerns, however, the model is useful as a tool for showing the relative long-range costs of providing enrichment services with alternative mixes of enrichment technologies.

CURRENT DEMAND PROJECTIONS MAKE BUILDING THE GAS CENTRIFUGE PLANT UNECONOMICAL UNDER MOST CIRCUMSTANCES

Both DOE's enrichment strategy study and our evaluation of DOE's economic justification show that building the gas centrifuge plant at this time is uneconomical in the long run at an enrichment services demand level of 250 gigawatts or less in the year 2000. DOE's current estimate of demand by that year is 266 gigawatts, but we believe demand will probably be between 184 and 217 gigawatts. The reason that demand is so important is that spreading the gas centrifuge plant's high capital cost--$7 billion in 1983 dollars--and imputed interest on this Government investment over a low level of enrichment services raises the cost of production from the gas centrifuge facility relative to that of the existing gaseous diffusion plants.

In its 1980 "Uranium Enrichment Strategy Study," DOE assumed low and high demand levels of 250 gigawatts and 350 gigawatts in the year 2000 for most of the "base cases" it analyzed. The "base cases" also assume an introduction date for advanced isotope separation enrichment capacity of either 1990, 1995, or no introduction.

DOE's study showed that at either the low demand of 250 or the high demand of 350 gigawatts in the year 2000, not building the gas centrifuge plant and continuing to use the gaseous diffusion plants while bringing an advanced isotope separation facility on line in 1990, if available, was the lowest cost alternative. If an advanced isotope separation facility is not available until 1995, DOE's study showed that building the gas centrifuge plant is economical at a high demand of 350 gigawatts but is not economical at a lower demand of 250 gigawatts in the year 2000. At the lower demand figure, according to DOE's study, it is cheaper in the long run to rely on the gaseous diffusion plants and advanced isotope separation facilities beginning in 1995 than to build the gas centrifuge plant.

Our analysis of the likely demand for DOE enrichment services and the effects of this demand on the economics of building the gas centrifuge plant confirmed DOE's own findings. As indicated in chapter 2, we believe the demand for DOE enrichment services in the year 2000 will likely be between 184 and 217 gigawatts. Therefore, we reran DOE's computerized model using these two levels of demand. For all other assumptions used in the model, we used the values which DOE currently uses in its enrichment planning. For example, we used DOE's current estimate of gas centrifuge plant construction and operating costs and its projections of the rate of electric power cost escalation. When the demand input is lowered to 217 gigawatts in the year 2000, the present value cost of providing enrichment services over a 31-year period is about $59.5 billion if the gas centrifuge facility is built and $58.7 billion if it is not built, or $800 million less. At the lower 184 gigawatts demand level, the model shows that on a present value basis it would be $1.4 billion more expensive to provide enrichment services over this same period by building the gas centrifuge plant than if it were not built.

THE GAS CENTRIFUGE PLANT IS NOT ECONOMICAL IF AN ADVANCED ISOTOPE SEPARATION ENRICHMENT TECHNOLOGY BECOMES AVAILABLE

Since 1973 DOE has been conducting research on three competing advanced isotope separation uranium enrichment technologies. DOE's principal goal is to develop one of these technologies to the point where it is capable of producing enriched uranium for nuclear power plants at a cost of less than $40 (fiscal year 1983 dollars) per separative work unit. By comparison, DOE estimates that it will be able to enrich uranium in the new gas centrifuge plant at a cost of about $81 per separative work unit (fiscal year 1983 dollars); and in fiscal year 1981, DOE's cost of enriching uranium in its existing gaseous diffusion plants was about $87.50 per separative work unit.

Through fiscal year 1982, DOE will have spent about $400 million on this research program to establish the scientific feasibility of the three technologies. In April 1982, DOE selected one of these technologies for further development. Using this technology, DOE plans to design, construct, and test a prototype plant by fiscal year 1988. Two key objectives are to (1) develop a firm data base from which to project production plant economics, and (2) establish that DOE can proceed to a production-scale facility with low to moderate technical risk.

Successful completion of the prototype plant, DOE believes, should give it a reasonably firm basis for comparing the relative costs of enriching uranium with the selected advanced isotope technology and the gaseous diffusion and gas centrifuge technologies.

At present, DOE has established the scientific feasibility of the technology, and believes it can have a production size advanced isotope separation enrichment plant capable of meeting its cost objective on line by the mid-1990s. Although there are remaining uncertainties, DOE's current cost projections contain large (about 30 percent of total cost) cost contingencies.

DOE's strategy study showed, and our analysis confirmed, that the availability of an advanced isotope separation facility, in conjunction with demand, largely determines whether or not construction of the gas centrifuge plant is economical. For example, DOE's study, as stated earlier, showed that if an advanced separation facility is available in 1995, building the gas centrifuge plant is economical in the long run only if demand in the year 2000 is at the 350 gigawatt level--84 gigawatts above DOE's current projection and 133 gigawatts above our own high estimate.

If DOE's advanced isotope separation program fails--if it does not work as anticipated or costs are considerably greater than anticipated--then building the gas centrifuge plant becomes more economical in the long run even at low demand levels. For example, using DOE's computerized model we calculated the present value of the long-range cost of providing enrichment services with (1) the gaseous diffusion plants only and (2) with the gaseous diffusion plants and the gas centrifuge plant. At 217 gigawatts demand level, a combination of the gas centrifuge plant and the gaseous diffusion plants was clearly the more economical choice. At 184 gigawatts demand level, building the gas centrifuge plant was only slightly more economical over the 31-year period.

The above discussion does not account for a slip in the introduction date for an advanced isotope separation enrichment facility. In its strategy study, DOE tested the impact of a 2-year (1995 to 1997) delay on introduction of an advanced isotope separation facility using a demand level of 250 gigawatts in the year 2000. DOE's study showed that this delay would have little impact on its findings that building the gas centrifuge plant is uneconomical if an advanced separation technology is available by 1995.

OTHER FACTORS ADVERSELY AND FAVORABLY AFFECT GAS CENTRIFUGE PLANT ECONOMICS

With DOE's assistance, we identified other key assumptions used in DOE's economic analysis, which, if changed, can materially affect the long-range economics of building or not building the gas centrifuge plant. They include gas centrifuge plant capital and operating costs, future electric power costs, and the discount rate used in the analysis to put estimated future costs of various alternatives on a present value basis for comparative purposes.

Based on our work, we believe that DOE

--did not provide for the uncertainties inherent in building a first-of-a-kind facility when it estimated gas centrifuge plant construction and operating costs,

--overestimated future electric power cost escalation rates, and

--used a discount rate in its analysis which was too high.

The effect of the first two items was to favor construction of the gas centrifuge plant, while the reverse was true for the latter item.

The following sections discuss the reasons why we believe DOE should have used different values for these key assumptions in its economic analysis. It also discusses the effects of changing these values, in conjunction with our high and low demand estimates and the availability of an advanced isotope separation facility in 1995, on the long-range economics of building or not building the gas centrifuge plant.

Adjusting gas centrifuge plant cost estimates to recognize uncertainty makes the plant even less economical

DOE expects that the cost of procuring the tens of thousands of centrifuge machines required for the gas centrifuge plant will comprise about 40 percent of the plant's capital costs. Furthermore, centrifuge machine performance--the frequency of repairs and replacement of centrifuge machines--is expected to be the key determinant of plant operating costs.

In estimating the initial acquisition cost and operating costs of the centrifuge machines and the many related components and systems, DOE principally relied on its years of experience in developing centrifuge machines up to and including prototypes of the machines it plans to initially install in the two process buildings under construction. Although we found that both the centrifuge machine development program and the gas centrifuge plant construction project are generally proceeding within cost and schedule objectives, the reliability of the advanced machines and related components is still uncertain, and no fixed price contracts have been awarded for machine procurement. To date, DOE has acquired and is testing 45 prototype machines. However, only 15 (5 each) of the machines were fabricated by the three firms competing for centrifuge machine supply contracts. Furthermore, none of these machines have been produced on the mass production basis that will eventually be required to supply the tens of thousands of machines to be installed in the plant. Finally, DOE has not yet built or tested a prototype of the advanced centrifuge machine it intends to install in the last

six process buildings of the facility and to eventually install in the first two process buildings as replacement machines.

The above discussion highlights the uncertainty of what the actual gas centrifuge plant capital and operating costs will be. Any new first-of-a-kind project, such as the gas centrifuge plant, is subject to potential cost growth because of the unknown, and clearly there are remaining unknowns at this stage of centrifuge machine development and gas centrifuge plant construction. DOE, however, did not recognize this in assigning values for gas centrifuge plant capital and operating costs for the purpose of its long-range economic analysis. To test the sensitivity of cost overruns on the economics of building the gas centrifuge plant, we increased DOE's estimate of the plant's operating and capital costs by 10 percent. This is not unreasonable in view of historical cost overruns on Federal projects.

When DOE's estimates of operating and capital costs were increased by 10 percent and demand changed to 217 gigawatts, building the gas centrifuge plant became even more expensive. In this case, DOE's computerized model showed that the discounted 31-year cost of providing enrichment services would be about $60 billion if the gas centrifuge plant is built and $58.7 billion if it is not--a difference of $1.3 billion. When the 10 percent increase was made in conjunction with a change in demand to 184 gigawatts in the year 2000, DOE's computerized model showed that over the long range, building the plant would result in enrichment services costs of $57.7 billion, on a present value basis, and $55.8 billion if the plant is not built.

DOE used a high electric power cost escalation rate which favors building the gas centrifuge plant

We believe the electric power cost escalation rates DOE used in its economic analysis are too high. The electric power cost escalation rates are important in determining the long-range costs of providing enrichment services with and without the centrifuge plant because the existing gaseous diffusion plants use much more electricity than the centrifuge plant is expected to use. Therefore, a high electric power cost escalation rate increases the estimated cost of gaseous diffusion plant operations relative to the estimated operating costs of the centrifuge plant.

In its economical analysis, DOE escalated electric power costs relative to capital expenditures and non-power operating costs. In doing this, DOE used an escalation rate of about 3 percent through 1990 and about 1-1/2 percent thereafter. This implies that if capital expenditures and non-power operating costs were to escalate by 9.15 percent annually through 1990, and by 8.15 percent thereafter, electric power costs would escalate by 12.4 and 9.77 percent, respectively.

Using the Energy Information Administration's 1981 annual report to the Congress in conjunction with an econometric model developed by Data Resources, Inc., we independently calculated electric power cost escalation rates through the year 1990 and thereafter. Our analysis showed that, based on constant prices for capital expenditures and non-power operating costs, electricity costs would escalate at a rate of 0.4 percent through the year 1990 and not at all thereafter. This implies that given the previously cited escalation rates for capital expenditures and non-power operating costs, electric power costs would escalate at 9.56 percent annually through the year 1990, and 8.15 percent annually thereafter. Neither DOE's nor our own projected electric power cost escalation rates are tied to the specific utilities which supply DOE with electric power. Our projection, however, is consistent with the Energy Information Administration's power cost escalation rates for the regions where the existing gaseous diffusion plants are located.

Using our calculated electric power cost escalation rates in conjunction with 217 gigawatts of demand for DOE enrichment services in the year 2000, DOE's computer model shows that it would cost about $57.1 billion to provide enrichment services over the 31-year period if the centrifuge plant were built and $55.6 billion if it were not--a difference of $1.5 billion. At our lower demand figure of 184 gigawatts, the difference was $1.8 billion on a discounted basis.

The high discount rate DOE used in its economic analysis does not favor gas centrifuge plant economics

In determining the long-range costs of providing enrichment services with and without the centrifuge plant, DOE discounted future costs by a rate of 10 percent. According to DOE officials, they used the 10 percent rate to comply with Office of Management and Budget Circular Number A-94, revised. We do not believe Circular A-94, revised, is appropriate for this situation. In our opinion, while this circular is suitable for determining whether or not a proposed investment should be undertaken by the Government, it is not to be used when performing a cost comparison to identify the most economical investment alternative.

To derive a discount rate that would be applicable to the DOE model which excludes inflation from its cost projections, we used the average yield--adjusted for anticipated inflation--on outstanding marketable U.S. Treasury obligations with remaining maturities comparable to the period of analysis. This approach indicates a maximum discount rate of 5 percent is appropriate for use in DOE's strategy study.

The 5 percent discount rate is more favorable to construction of the gas centrifuge plant than the 10 percent rate DOE used in its strategy study because constructing the plant requires

large expenditures in the early years. For example, at a demand level of 217 gigawatts in the year 2000 and a discount rate of 5 percent, DOE's computerized model shows that construction of the gas centrifuge plant would result in discounted long range enrichment services costs of $92.2 billion compared to $92.6 billion if the plant is not built--a savings of $400 million. However, when we adjusted DOE's assumptions on electric power cost escalation and gas centrifuge plant capital and operating costs in conjunction with a 5 percent discount rate, DOE's computerized model showed that it would still be more expensive to provide enrichment services over the long range if the centrifuge plant was built than if it was not. For example, if the gas centrifuge plant construction and operating costs are increased by 10 percent to reflect the uncertainty in this area (see p. 19), it becomes $340 million more expensive, on a present value basis, to provide enrichment services over the long run if the centrifuge plant is built than if it is not. The cost penalty of building the centrifuge plant would be even higher if demand is less than 217 gigawatts and/or electric power costs escalate at a slower rate than DOE expects.

THE GAS CENTRIFUGE PLANT IS UNLIKELY TO IMPROVE DOE'S COMPETITIVE POSITION IN THE ENRICHMENT MARKET

DOE's uranium enrichment marketing goal is to obtain as much of the foreign market as possible to promote U.S. nuclear nonproliferation objectives and improve the Nation's balance of payments. DOE believes constructing the gas centrifuge plant will help it achieve this goal in the long run by enabling it to reduce the cost (and price) of enrichment services, thus increasing foreign sales and improving our balance of payments. Considerable doubt exists as to whether construction of the gas centrifuge plant will enable DOE to accomplish either objective.

As discussed earlier, our evaluation of DOE's economic analysis revealed that there are apparently no definite long-range cost reduction benefits associated with constructing the gas centrifuge plant. However, even if one accepts DOE's position that building the centrifuge plant is economical, building the plant would not begin to reduce the average customer price for enrichment services until after 1992. DOE's most recent operating plan--a plan it periodically prepares for short- and long-range planning and budgetary requirements--shows that the average price for its enrichment services through 1992 is slightly higher with construction of the gas centrifuge plant than without the plant. The reason for this is that the cost of enrichment services production from the portions of the plant scheduled for full production in fiscal years 1989 through 1992 is expected to be higher than the cost of production from the existing gaseous diffusion plants.

Also, if DOE is able to offer cheaper enrichment prices, our past work has revealed that it is unlikely to improve DOE's competitive position in the world enrichment market. When we evaluated the Nuclear Non-Proliferation Act of 1978, 1/ we learned that many potential foreign enrichment customers were more interested in diversifying their sources of enrichment services than in obtaining the lowest enrichment prices. This diversification phenomenon has apparently been borne out, because since reopening its enrichment services order books in 1978, DOE did not sign a new foreign enrichment contract until May 1982, despite a vigorous marketing effort and one of the lowest enrichment prices available. 2/

Non-proliferation benefits are minimal

DOE believes that building the gas centrifuge enrichment plant has non-proliferation benefits because it will enable DOE to obtain a larger share of the foreign enrichment market. This, according to DOE, offers non-proliferation benefits because it expands the U.S. involvement in foreign nuclear programs. As we stated in our November 1980 report, however, there is little evidence that building the centrifuge facility will increase DOE's share of the foreign enrichment market because the primary objectives of potential foreign customers is to obtain an assured source of enriched uranium to fuel their expensive nuclear power plants.

Given the nature of U.S. export policies and practices, it apparently is not possible for the United States, at this time, to offer the long-range supply assurances considered important by many foreign users of enriched uranium. For example, the nuclear non-proliferation policies of the Ford and Carter Administrations have been cited by some foreign customers as factors influencing decisions to seek enrichment services from non-U.S. suppliers. In fact, foreign officials have noted that they have no assurance that the next administration or the Congress will not unilaterally revise the conditions governing the U.S. export of enriched uranium as it did in the Nuclear Non-proliferation Act of 1978. An indication of this sentiment is the clause inserted in U.S. enrichment contracts, at the foreign customers' requests, that the customer has the right to terminate the contract at no charge in the event the United States adds any new statutory export conditions.

1/"Evaluation of Selected Features of U.S. Nuclear Non-Proliferation Law and Policy," EMD-81-9, Nov. 18, 1980.

2/Until 1981, U.S. enrichment services were the cheapest, with the exception of the Soviet Union, which apparently underpriced the United States as a matter of policy. In 1981, EURODIF reduced its charge for enrichment services to a price lower than the U.S. price.

Even if building the centrifuge plant were to increase the U.S. share of the foreign enrichment market, it would only offer nominal non-proliferation benefits to the United States. As we reported to the Congress in November 1980, we believe the desires of prospective foreign customers to diversify their sources of supply for enrichment services has a number of advantages from a non-proliferation standpoint. Although it reduces the amount of U.S. direct involvement, the opportunities for diversification offer far more assurance of supply to customer countries which do not now have enrichment capabilities than did the earlier U.S. controlled market. This should make it more difficult for these countries to justify to the world community a need to develop their own enrichment capabilities.

Balance of payments benefits are small

In recent congressional testimony, DOE officials stated that by maintaining and expanding its enrichment sales to foreign customers, the United States would realize significant balance of payments benefits. While we agree that it is important for the United States to improve its balance of payments, it is important to put those benefits related to DOE's foreign enrichment services sales in perspective when deciding whether or not to spend billions of near-term dollars on building an enrichment plant. In fiscal year 1980, for example, DOE's foreign sales of its enrichment services totaled $454 million. Although a sizeable amount, this represented only slightly more than one-tenth of one percent of total U.S. export revenues for that year. Even if DOE's track record for obtaining new foreign enrichment customers unexpectedly improved, and DOE was able to get new foreign customers, the revenues from these customers would only represent a small increase in total U.S. revenues from exports.

DOE'S COMPUTERIZED MODEL CONTAINS TECHNICAL PROBLEMS AND CANNOT BE VALIDATED

To evaluate the validity of the computerized model DOE used to make its strategy study and to determine the long-range costs of enriching uranium, we reviewed two basic aspects of the model. First, we analyzed the mathematics underlying the model to determine whether or not they accurately represented the physical and economic realities of enriching uranium. The mathematical model contains the mathematical equations which the computer solves in order to project long-range costs of enrichment services. Second, we examined the results of the model to determine whether or not the computer was accurately executing the model's mathematical equations. In examining these two areas, we found that

--DOE failed to adequately document the model;

--DOE constrained the model;

--the model does not, in one instance, reflect economic reality; and

--the computer incorrectly executed a portion of the model.

These shortcomings prevented us from validating the model. They also raise questions about the accuracy of the total long-range enrichment services costs calculated by the model under various assumptions of demand for enrichment services, costs of building and operating enrichment plants, and mixes of enrichment technologies. This does not necessarily, however, make the model useless for cost comparison purposes. While the model may not accurately calculate total enrichment services costs, it is useful for determining which mixes of enrichment technologies--for example, building or not building the gas centrifuge plant-- is most cost effective in the long run on a relative basis.

DOE failed to adequately document the model

GAO's "Audit Standards for Auditing Computer-Based Systems," require that an agency maintain documentation of a computer system sufficient to provide a level of understanding of the system necessary for appropriate maintenance and auditing. Thus, as part of its normal computer related activities, an agency should compile that data which would be needed for an independent organization to review and understand the computer system in question. During our review of DOE's model, we found that it failed to maintain adequate written documentation for the mathematical model. This situation would prevent us, DOE management, or any other independent organization from validating the accuracy and appropriateness of the mathematical model without extensive consultation, which we found necessary in this instance, with personnel familiar with the model.

The primary documentation supporting the accuracy and appropriateness of the mathematics of DOE's computer model is a magazine article published almost 13 years ago. 1/ This article, however, is inconsistent and imprecise in its use of mathematical notations. Furthermore, DOE has not maintained adequate written documentation describing a number of modifications that have been made to the computer program since it was developed. This lack of documentation precludes adequate identification and evaluation of the effects of all the modifications that have been made to the program.

1/"Enriched Uranium Production Planning," D.E. Ratch and S.A. Levin, Union Carbide Corporation, in Nuclear Applications & Technology, Vol. 7, July 1969, reprinted as an appendix to DOE's strategy study.

DOE constrained the model

The computerized model used in the strategy study is designed to determine the (1) optimum ratio of uranium feed 1/ to electric power and (2) the optimum rate of production. We found that DOE did not allow the model to optimize these two functions as it is intended to do, but instead constrained the model by using input to the model which already specified the exact ratio of feed to electric power and the precise electric power levels. Misstating these parameters would cause the results to be incorrect.

DOE officials were unable to satisfactorily explain to us (1) why they constrained the model in this way and (2) the impact this constraint had on the computerized analysis. They stated that the input data came from previous unconstrained runs of the model, and therefore already represented the optimum feed to power ratios and the optimum electric power levels. We were unable to verify this, however, because DOE did not save the computer printouts which could have supported this explanation. Furthermore, we received conflicting explanations from officials of DOE and its contractor as to why the optimization data had to be generated by an earlier computer run to begin with. The DOE official told us that an earlier computer run was necessary to reduce the amount of computer time required to run the program. The contractor official, on the other hand, explained that the separate run was needed to remove technical difficulties the program encountered in pricing feed.

DOE's model does not, in one area, reflect economic reality

As discussed previously, the computerized model is designed to optimize the ratio of uranium feed to electric power as part of its determination of the most efficient way to operate the enrichment facilities. Because the determination of the optimum ratio of uranium feed to electric power is dependent on the relative costs of these two factors, it is important that realistic costs for each be used if accurate results are to be obtained.

Our review of the computerized model revealed that it determines uranium feed costs in a manner which results in unrealistic feed costs being used in the model's determination of the optimum mix of uranium feed to electric power. Basically, this problem occurs because the model values that portion of the feed

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1/Uranium feed is natural uranium which has been converted to a gaseous compound called uranium hexafloride after mining and milling. It is this product which DOE feeds into its enrichment plants for the purpose of enriching it in its content of the fissionable uranium isotope uranium-235.

which comes from DOE's stockpile at the estimated market price DOE believes will exist in the year its entire uranium feed stockpile 1/ is used up. This value is then reduced by discounting it to the years in which the feed is actually used, causing the feed to be valued substantially below true market price. As a result, the model uses too much feed and not enough electric power.

The computer incorrectly executed the uranium feed portion of the mathematical model

DOE developed the computerized model to assist in determining the most economic method of operating its enrichment facilities. The model consists of numerous mathematical equations which, although they could be solved by hand, are solved much more quickly by a computer. Thus the computer's role is simply to execute the mathematical equations included in the model.

We found that the computer did not accurately implement the model's mathematics and therefore did not determine the most economic mode of operation for the enrichment facilities in the way the model intended it to. Specifically, the computer did not use a value for uranium feed consistent with the value the mathematical model requires. Instead of using a value for feed equal to its projected value at the time the entire feed stockpile is depleted, as required by the model, the computer program used various other years.

1/DOE has a stockpile of uranium feed as the result of AEC's purchase of large quantities of uranium in past years to support the developing uranium mining industry.

CHAPTER 4

BUDGETARY IMPACTS OF GAS CENTRIFUGE PLANT CONSTRUCTION OPTIONS ARE SIGNIFICANT

Through the end of fiscal year 1982, DOE estimates that it will have spent about $1.2 billion on the gas centrifuge plant project, and estimates that the project will cost about $7 billion (fiscal year 1983 dollars) in total. While this cost would ultimately be borne by DOE's customers, there are, nevertheless, significant budgetary impacts associated with building the plant. With respect to these impacts, we believe there are four basic options which could be followed. They are:

--Continue the project on schedule. This would require an additional $5.5 billion in appropriations through fiscal year 1994.

--Terminate the entire gas centrifuge plant construction project immediately. This would reduce the need for appropriations through 1994 by about $5.1 billion.

--Complete only the portion of the gas centrifuge plant project now under construction. This would require an additional $2.2 billion in appropriations. Also, enrichment operations from this portion of the plant are, according to DOE, expected to be more costly than the operating costs of the gaseous diffusion plants.

--Slow the project one or more years. According to DOE, this would reduce the need for appropriations in the early years but require higher appropriations in the later years and would add to the total cost of building the plant.

Unless otherwise noted, all dollar amounts discussed in this chapter are expressed in fiscal year 1983 dollars.

BUDGETARY IMPACTS OF COMPLETING THE GAS CENTRIFUGE PLANT ON SCHEDULE

By the end of fiscal year 1982, DOE expects that it will have spent about $1.2 billion of the $1.5 billion it has been appropriated to build the gas centrifuge plant. Most of these funds will have been spent on (1) partial construction of two of the eight planned centrifuge machine process buildings, (2) partial or complete construction of many other facilities which will support the entire plant and (3) site preparation for all centrifuge machine process buildings.

DOE estimates it will need to spend an additional $5.8 billion between 1983 and 1994 to complete the project as shown in the following table.

Gas Centrifuge Construction
Funding Plan (note a)

Fiscal year	Construction costs
1983	$ 525
1984	600
1985	600
1986	585
1987	610
1988	615
1989	615
1990	575
1991	415
1992	295
1993	193
1994	124
Total	$5,752

a/These figures exclude start-up and operating costs over the years indicated, escalating from $13 million to $227 million per year by 1994; and technical support and test facility activities of $73 million per year.

These funds, and interest on them, will eventually be paid back to DOE by its enrichment services customers, beginning in 1989, over the operating life of the plant. DOE includes in its price for enrichment services an amount for depreciation on its enrichment plants and an amount for interest on the use of Federal funds to construct its enrichment plants. DOE currently plans to depreciate the gas centrifuge plant over a 25-year period.

BUDGETARY IMPACTS OF TERMINATING THE GAS CENTRIFUGE PLANT

Termination of the entire gas centrifuge plant project would eliminate the need for most of the $5.8 billion in additional expenditures planned in fiscal years 1983 through 1994. According to DOE, it would need about $350 million of fiscal year 1983 funds to pay project termination charges over and above paying the approximately $342 million in outstanding commitments with funds already appropriated.

If the gas centrifuge plant project were terminated, DOE would not have the first increment of the plant to put into full operation in 1989 as currently planned. Therefore, DOE would have to use more of its existing gaseous diffusion capacity

than it currently plans to use. Using more gaseous diffusion plant capacity increases DOE's electric power requirements and costs. It is unlikely, however, that DOE would need additional appropriations to purchase this electric power, because the price it charges its customers for enrichment services includes a change for electric power costs.

BUDGETARY IMPACTS OF COMPLETING THE PORTION OF THE GAS CENTRIFUGE PLANT NOW UNDER CONSTRUCTION

DOE estimates that it would cost $3.7 billion--or another $2.2 billion over what has already been appropriated--to complete the two centrifuge machine process buildings now under construction plus necessary related facilities. In total, this is over one-half the cost of building the entire plant. DOE currently plans to complete the first two process buildings and related facilities in 1989. Thus, an additional $2.2 billion in appropriations would be required in fiscal years 1983 through 1989. As discussed earlier, these funds, plus interest, would eventually be recovered over the facility's operating life.

While the short-term budgetary impacts of this option are less than the budgetary impacts of building the entire gas centrifuge plant, there is an enrichment services cost penalty associated with this option.

DOE estimates that the cost of enriching uranium with the first centrifuge increment would be $266 per separative work unit. If this increment is later retrofitted with the advanced centrifuge machines now under development, the cost is expected to be $177 per unit. By comparison, in fiscal year 1981, the actual cost per unit from the existing diffusion facilities was $87. The relatively high cost of production from the first increment would occur because the first increment, if completed, will cost one-half as much to build as the full plant, but will only be able to produce one-sixth the amount of enriched uranium. 1/ Therefore, each unit of output from the first increment will have to absorb a larger amount of depreciation, interest, and fixed costs than if the full plant were built with its much greater capacity. Thus, completing and operating only the first

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1/This first segment of the centrifuge plant is expected to initially have an enrichment capacity of 2.2 million separative work units. At a later date, DOE plans to retrofit this segment with more advanced centrifuge machines. DOE expects this to increase the capacity by 50 percent to 3.3 million separative work units. Thus the first segment initially has one-sixth the capacity of the entire plant's expected 13.2 million separative work capacity. When retrofitted, the first segment would have one-quarter the capacity of the full plant.

increment of the centrifuge plant would increase, rather than lower, the unit cost of DOE's uranium enrichment operations.

BUDGETARY IMPACTS OF SLOWING THE GAS CENTRIFUGE PLANT CONSTRUCTION SCHEDULE

In its December 1981, operating plan, DOE examined the budgetary impacts of stretching out the construction schedules for completing the last six centrifuge machine process buildings by 1, 2, and 4 years. Overall, DOE estimates that these longer project schedules would increase total project appropriation requirements by $285 million, $450 million, and $724 million, respectively.

According to the estimates in DOE's operating plan, these schedule slippages would have the following general impacts:

--A 1-year slip would reduce total appropriations for the 6 fiscal years beginning in 1983 and ending in fiscal year 1988 by $151 million. This savings would be offset in the remaining 7-year construction period ending in fiscal year 1995 by additional appropriations requirements of $436 million, for a net increase of $285 million.

--A 2-year slip would reduce total appropriations for fiscal years 1983 through 1988 by $222 million but would increase appropriations over the next 8 years by $672 million, or a net increase of $450 million.

--A 4-year slip would reduce total appropriations for fiscal years 1983 through 1988 by $468 million, but would increase appropriations over the next 10 years by $1.192 billion, or a net increase of $724 million.

CHAPTER 5

OBSERVATIONS, CONCLUSIONS, AND MATTERS FOR CONSIDERATION BY THE CONGRESS

Building the new gas centrifuge plant will have significant budgetary impacts through fiscal year 1994--at a time when increasing attention is being given to holding down Federal expenditures. DOE has asked for $525 million in fiscal year 1983 to continue constructing the plant, plans to request about $600 million more each budget year from 1984 through 1990, and will request lesser amounts thereafter through 1994.

In view of the short term budgetary impact, the Congress should closely examine the validity of the justification for building the new plant. DOE believes that the plant is needed to (1) satisfy future demand for its enrichment services, (2) minimize long-range costs of providing these services and, therefore, (3) enable it to more effectively compete in the world enrichment services market. DOE believes the latter is important both from a nuclear non-proliferation and a balance-of-payments standpoint.

We found, however, that building the plant is not justified on the above grounds. First, demand for DOE enrichment services is likely to be substantially less than DOE predicts. This makes it possible for DOE to satisfy demand up to and beyond the year 2000 with its existing enrichment capacity. Thus, from a demand standpoint there is no need to build the new gas centrifuge plant at this time.

Second, it is not apparent that by constructing the new gas centrifuge plant DOE will be able to reduce the costs of providing enrichment services over the long run. This is because demand for enrichment services is by far the most critical factor affecting the economics of the plant. DOE's own study, for example, showed that building the centrifuge plant is economical only if (1) an advanced isotope separation facility is not available or (2) demand by the year 2000 approaches 350 gigawatts--84 gigawatts above DOE's current estimate. Our own analysis confirmed DOE's findings. At our 217 gigawatt-high demand, DOE's computerized model showed that building the gas centrifuge plant is economical if DOE is unable to develop a more cost efficient advanced isotope separation technology.

While the economics of building the gas centrifuge plant are primarily driven by demand, other factors also affect the economics. For example, in preparing its economic justification, DOE overestimated future electric power costs and did not consider the cost uncertainty inherent in a first-of-a-kind facility like the gas centrifuge plant. Lowering estimates of future electric power costs and increasing gas centrifuge plant construction and operating

costs to recognize the present cost uncertainty makes constructing the gas centrifuge plant even less economical. On the other hand, DOE used too high of a discount rate in determining the present value of long-range enrichment services costs. Discounting long-range costs using a lower--and we believe more accurate--discount rate reduced the long-range economic penalty of building the gas centrifuge plant. Finally, we also found technical problems and a lack of written documentation in the computerized model DOE used in its economic analysis. The model is, however, useful as a tool for showing the relative long-range costs of providing enrichment services with alternative mixes of enrichment technologies. One should recognize, however, that the economic analyses based on the model depend on projections of costs and other assumptions 31 years into the future.

Third, even if, as claimed by DOE, a gas centrifuge plant results in lower enrichment services prices to DOE's customers, constructing the plant is unlikely to significantly improve DOE's competitive foreign market position. This is because prospective foreign customers consider much more than price when selecting an enrichment services supplier. For example, assurances of supply and desire to diversify supply sources have apparently played important roles in foreign decisions on where to obtain their enrichment services. This has occurred despite DOE's historically competitive price. The U.S. loss of its enrichment monopoly with the emergence of non-U.S. enrichers in the 1970s, as well as the future plans of other nations--such as Japan and Australia--to enrich uranium for themselves or others, further reduces the likelihood of the centrifuge plant significantly improving DOE's competitive foreign market position. Also, like in this country, there has been a general decline in once ambitious foreign nuclear plant plans. Thus, it is highly unlikely that the new centrifuge plant would enable DOE to significantly enhance U.S. nuclear non-proliferation objectives, or increase the U.S. balance of payments through increased exports.

Through fiscal year 1982, DOE estimates that it will spend about $1.2 billion on the gas centrifuge plant. These funds are primarily being spent on construction of two of the eight planned centrifuge machine process buildings and some of the related facilities designed to service the entire plant. DOE plans to complete and begin operating this initial increment by 1989, and to incrementally complete the remaining six process buildings by 1994. In view of the progress to date on the plant and our conclusion that the plant is not justified on the basis put forth by DOE, we determined the budgetary impacts of

--completing the plant on schedule,

--terminating the plant,

--completing only the portion now under construction, and

--stretching out the plant construction schedule.

Completing the plant on schedule will require an additional $5.5 billion in appropriations from fiscal years 1983 through 1994. Terminating the project, on the other hand, would eliminate, according to DOE, the need for all but about $350 million of fiscal years 1983 appropriations to pay termination charges over and above paying approximately $342 million in outstanding commitments with funds already appropriated.

Completing only the portion of the plant under construction would require another $2.5 billion in expenditures in addition to the $1.2 billion spent. Thus, completing only the portion now under construction would cost, in total, over one-half the cost of building the entire plant, but would initially have only one-sixth, of the expected full-plant capacity. Eventually, this portion could have one-fourth of the capacity of the full plant if DOE developed and retrofitted more advanced machines in the plant. According to DOE, enrichment operations from only this portion of the gas centrifuge plant would not be cost effective, and therefore, would increase the price DOE would charge for enrichment services. Specifically, DOE estimates that it would cost about three times as much to enrich uranium in the scaled-down plant as it would in the entire plant, and about twice as much as in the existing diffusion plants even if the scaled-down plant is retrofitted with the advance centrifuge machines.

Thus, strictly from the standpoint of the cost of enriching uranium it makes more sense to build the entire plant than it does to stop construction once the portion now under construction is completed.

Stretching out the gas centrifuge plant project construction schedule, according to DOE, would offer short-term budgetary savings at the expense of larger appropriations in the later years of the project. For example, DOE believes a 2-year slip would reduce total appropriations requirements by $222 million through fiscal year 1988, but would subsequently increase DOE's appropriation requirements over the following 8 years by $672 million.

From the above discussion and the evidence presented in this report, construction of the entire gas centrifuge plant or the portion now under construction is not justified on the basis put forth by DOE. We recognize, however, that other factors--some of which we did not address in our evaluation--should also be considered in deciding on the future of this major Federal project. Chief among these, we believe, is the outlook for nuclear power. Despite the deterioration in this country's nuclear power program, many believe that ultimately the Nation will again turn to nuclear power. While a sharp reversal in nuclear power's fortunes could occur, we believe it is unlikely to occur soon or with great speed. First, it is possible that additional cancellations of plants now on order will exceed new

orders in the 1980s. Second, an improvement in the outlook for nuclear power would take several years to occur. Once utilities begin to order new nuclear power plants, current experience indicates that it will likely take from 12 to 14 years to bring these plants on line. Thus, even a dramatic improvement in the outlook for nuclear power will not significantly increase demand for DOE enrichment services until around the year 2000.

In addition, as with any economic analysis, some of the key assumptions used in projecting the economics of building the gas centrifuge plant by both us and DOE must be viewed with caution. Key among these uncertain assumptions is the promise and the uncertainty of advanced isotope separation enrichment technology. DOE currently believes this technology could be available as early as the mid-1990s and enrich uranium for one-half the cost of gas centrifuge technology. There are, however, remaining uncertainties, and thus far only its scientific feasibility has been established. If DOE is correct in its assessment, neither the gas centrifuge nor the gaseous diffusion technologies will be cost competitive with the advanced separation technology. If DOE is unable, however, to develop an advanced separation technology that is less costly than gas centrifuge technology, then building the gas centrifuge plant is economical.

Finally, the factors identified earlier that were outside the scope of our review, such as the impacts of increasing or decreasing gaseous diffusion plant operations on TVA's electric power system, should also be considered.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Our work shows that building the centrifuge plant is not justified at current expected demand levels. On the other hand, constructing the plant is economical if events cause a sudden increase in the demand for nuclear power or if DOE's efforts to develop advanced isotope separation technology fail. If either of the events occur, however, DOE has sufficient time to build new capacity.

There are, however, other considerations that the Congress should weigh in addition to the information presented in this report. These considerations revolve around judgments about such things as the future growth of nuclear power, the social impacts of terminating the plant, the availability of electrical power, and the advantages to TVA of DOE using additional power for the gaseous diffusion plants if the centrifuge plant is not built. The Congress should consider the information presented in this report along with information on these other factors in making future funding decisions on the gas centrifuge plant.

In addition, because of the economic disadvantages of only completing the first portion of the plant, we believe that the Congress should view a decision to complete that increment as a commitment to building the entire plant.

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