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**Uranium Enrichment
Management Review**

Summary of Analysis

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Introduction

The uranium enrichment enterprise of the United States Department of Energy (DOE) provides enriched nuclear fuel for private and government utilities at home and abroad. The enterprise, in effect, provides a commercial service and represents a significant business operation within the U.S. government: more than \$1 billion in revenues annually and future capital expenditures estimated at several billions of dollars. As a result, in May 1980, the Assistant Secretary for Resource Applications within DOE requested that a group of experienced business executives be assembled to review the operation, financing, and management of the uranium enrichment enterprise as a basis for advising the Secretary of Energy. The review group was specifically asked to focus on the management activities to which sound business practices could be applied.

With Mr. Philip G. Sewell of DOE acting as executive secretary and liaison with Resource Applications, the following top-level executives comprised the group. Mr. Paul E. Sullivan serves as chairman of the board of the National Council of Better Business Bureaus and director of Hajoca Corporation, CHB Foods, Inc., Beneficial Standard Corporation, and American Medical International. Until 1979, he held the post of executive vice president for general management at Southern California Headquarters, Bank of America North America and South America. From 1968-1980 he has worked with the Los Angeles area Chamber of Commerce attaining the rank of chairman of the board in 1978. In 1969, he studied management techniques in the Advanced Management Program, Harvard Business School.

Another member of the management review group, Mr. Julian D. Ellett, retired from Du Pont in 1978 with 42 years of service in the nuclear field, which culminated in his post as general manager of the Petrochemicals Department from 1973-1978. He had the responsibility for operating the Savannah River Plant and Laboratory, a contract Du Pont held with DOE.

A third review group member, Mr. William B. Rieke, retired in 1980 as group vice president for Lockheed Corporation. In this post he was chairman of the boards of directors for three Lockheed subsidiaries -- Lockheed Electronics Company, Inc., Lockheed Petroleum Services Ltd., and Lockheed Shipbuilding and Construction Company. Until recently he was also chairman of the board of directors of Lockheed Missiles and Space Company, Inc. In addition to his Lockheed responsibilities, Mr. Rieke is a director of Transco Products, Inc., Los Angeles, California, and Western Digital Corp., Newport Beach, California.

The final member of the management review group, Mr. John W. Simpson, recently retired as president, Power Systems Co. (nuclear power division), Westinghouse Corporation, Pittsburgh. From 1937-58 Mr. Simpson was associated with the Bettis atomic power division becoming general manager, 1959-62, then vice president of the electric utility group, 1963-69. In his distinguished association with the growth of nuclear technology, Mr. Simpson was a delegate to the First and Second International Conference on the Peaceful Uses of Atomic Energy (1955, 1958).

After extensive investigation, analysis, and discussion, the review group presented its findings and recommendations in a report on December 2, 1980. The following pages contain background material on which that final report was based. With the assistance of Resource Planning Associates, Inc. (RPA), the review group also explored other management activities that may improve current practices.

This report is arranged in chapters that parallel those of the uranium enrichment management review final report -- chapters that contain summaries of the review group's discussion and analyses in six areas:

- Management of operations and construction
- Long-range planning
- Marketing of enrichment services
- Financial management
- Research and development
- General management.

Further information, in-depth analysis, and discussion of suggested alternative management practices are provided in five appendixes:

- Background Information for August 25-28 Meetings
- Need for Strategic Planning
- Strategy Review: Office of Uranium Resources and Enrichment
- Approach to Assessing Foreign Enrichment Requirements
- Review of the Procedure for Establishing the Price for Separative Work.

1

MANAGEMENT OF OPERATIONS AND CONSTRUCTION

On August 27 and 28, 1980, the review group made a familiarization visit to the enrichment facilities to view plant and personnel firsthand.

After reading documents related to Oak Ridge Operations (ORO) and holding meetings in Washington at DOE August 25-26, we were well prepared to examine the Oak Ridge Operations office and receive staff briefings. Based on this visit, five aspects of the day-to-day operations required detailed comment:

- Daily operation of the diffusion plants
- Determination of minimum operating levels
- Steps to renegotiate power contracts
- Project stabilization agreement for Portsmouth
- Gas centrifuge construction commitment.

DAILY OPERATION OF THE DIFFUSION PLANTS

U.S. enrichment capability resides in three DOE-owned facilities located at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. Two contractors operate the three plants for DOE: Union Carbide for the Oak Ridge and Paducah plants and Goodyear Atomic Corporation for the Portsmouth facility. However, the ORO staff (278 government employees in 1980) provides overall guidance and direction to contractor operations at all plants.

All formal actions affecting operations and work performed by the diffusion plant contractors flow through a contract administration channel. Thus, all policy has one centralized point of contact for review, coordination, concurrence, and approval within DOE. Supporting this

formal channel is the close day-to-day interface between the ORO office and contractor personnel in areas of specific responsibility such as safety, finance, engineering, and budgeting. This network of informal relationships not only facilitates the contract administration function but also provides surveillance of the contractor's activities. See the attached chart (Exhibit 1.1) for a diagram of the administrative relationships for gaseous diffusion plant operations.

Both Union Carbide and Goodyear Atomic have operated diffusion plants for over 25 years. Based on our observations and on-site interviews, both contractors employ knowledgeable and experienced management staff. In 1980 contractor staff at the three plants totals nearly 13,000 people.

In 1945, the first plant began operating at Oak Ridge as part of the World War II effort to develop and produce nuclear weapons. The Atomic Energy Commission (AEC) later built the Paducah and Portsmouth plants, which began full production in 1954 and 1956, respectively. The three plants now operate as an integrated complex with the Paducah plant providing slightly enriched uranium for the other two plants to further enrich the uranium to attain the level required for most power reactor fuels.

Thus, although built to satisfy military requirements for enriched uranium, these three plants are today used primarily to provide enrichment services to domestic and foreign electric utilities. Until the mid-1970s these facilities were almost the sole source of enriched uranium for commercial nuclear reactors in the free world.

In our discussions with Office of Uranium Resources and Enrichment (OURE) staff, we learned that with day-to-day management operations of the Union Carbide and Goodyear Atomic contracts delegated to ORO, OURE sees its role as supervisory:

The OURE role in this respect is one of overview of the Oak Ridge Operations Office. The principal goals and objectives are established during the annual budget process. They include production level and costs, progress on the capacity expansion programs, process development goals, and expected progress on construction projects

Exhibit 1.1
Programmatic Relationships
Gaseous Diffusion Operations

— Program Direction
 - - - Programmatic Guidance
 - . - Day-to-Day Programmatic Coordination

SOURCE: Office of Uranium Resources and Enrichment,
 Department of Energy, 8-6-80.

in the gaseous diffusion plant (GDP) operations. Generally major maintenance or procurements are singled out for special management attention. Currently roof repairs to the major process building at all three sites and maintenance that was deferred because of interference with the capacity expansion programs are being treated in this manner. Procurement of tails storage cylinders has been placed in a recurrent annual line item project. Monthly reporting procedures have been established to report on these goals and explain variances when goals are exceeded or not met.

Although the actual audit and appraisal of the contractor performance is carried out by the Oak Ridge Operations Office, the results are reported to OURE. In specialized areas such as safeguards, security, health and safety, Oak Ridge is over-viewed by DOE headquarters personnel from the Environmental and Safeguards/Security Offices.

While ORO Office staff divisions are responsible for the follow-up of specialized functional areas, all activity is coordinated by the contract administrator for close liaison with technical program assignments (see Exhibit 1.2). Directed by Mr. H.D. Fletcher, the Enriching Operations Division has a staff of 29. The senior staff members interviewed for this study have many years of experience with the diffusion operations. Out of a total of 652 ORO personnel, this relatively small staff monitors the contractor operations through a system of performance evaluation and auditing. In this oversight administration the Office of Performance Evaluation gives support to the Enriching Operations Division. Based on our on-site evaluation, the contractor's performance is capable and effective.

DETERMINATION OF MINIMUM OPERATING LEVELS

U.S. requirements for enriched uranium are highly uncertain because growth in U.S. nuclear power and share of the

Exhibit 1.2
Contractor Oversight

- Long Range Operating Plan
 - Budget Assumptions
 - Budget Reviews
 - Program Reviews

 - Budget Submission
 - Financial Plan
 - Daily Contacts
 - Weekly Reports
 - Monthly Production Activities Report
 - Monthly Cost Reports
 - Site Visits
 - Quarterly Operating Plan
 - Interplant Operating Committee
 - Capital Equipment and GPP Directives

 - Appraisals
 - Specific Areas
 - Overall
 - Cost Plus Award Fee

 - Audits
-

SOURCE: Oak Ridge Operations Office, DOE, 8-26-80.

world market for enrichment services are both unpredictable. Although current contracts for DOE to supply enriched uranium are for 304 gigawatts (GWe) of nuclear power by the year 2000, it has become apparent that some of the reactors covered by these contracts will not be built. Recent demand has been lower than anticipated, and the diffusion complex is consequently operating at a 9.5 million separative work unit (SWU) production level, representing only 40 percent of capacity. In addition, the enterprise has built up an inventory of 30 million SWU.

To ascertain optimum production levels and timing of new capacity additions, OURE must determine more precisely the minimum production levels of the diffusion plants. A marginal cost analysis is used to schedule rates of production. However, the costs and technical feasibility of extended operations of the diffusion plants at substantially reduced production rates (shutting down of some process stages for extended periods) are not fully known. Very low operating levels could lead to deterioration of the diffusion barriers or other equipment failures. Some of the problems encountered during low-power operations and cells placed in standby are:

- Under the cascade improvement and upgrading programs (CIP/CUP), many of the improvements were specifically designed for high-power operations, and, consequently, at a late stage of CIP/CUP it is more difficult to operate the plant at low-power levels. As a result there is a greater risk of UF_6 freezeout (especially in cold weather) and an increased risk in fouling condensers, cooling tower degradation, and pumping problems in the high-capacity pumps at low-flow rates.
- Low-power operation requires some separation cells to be placed in standby, generally by evacuating the UF_6 process gas and replacing it with nitrogen or dry air. Careful monitoring of these cells is required, and there is concern for the integrity of the improved barrier under prolonged standby conditions.
- It is more difficult to control the equipment on-stream under low power conditions and surging; particularly at Paducah. When restarting, standby cells, seals, and compressors are often damaged, requiring increased maintenance.

At the direction of OURE, a research program was initiated by the operating contractor in spring 1980 to investigate the potential for barrier deterioration and degradation of the cascade components as a result of extended operation at reduced levels. However, the results of this effort will not be available for 2 years.

The research program should be given increased emphasis and accelerated to provide the information at an earlier date. The program should be designed to pinpoint the degradation of barriers and other equipment when stages are shut down during low levels of production. The scope of the program also should include an evaluation of whether the diffusion plants can be operated satisfactorily at lower levels of operation individually or as a complex.

STEPS TO RENEGOTIATE POWER CONTRACTS

In light of decreased demand and to minimize near-term costs, OURE plans to reduce its SWU production and hence its power purchases through 1986. In 1981 the enrichment plants are scheduled to operate at a power level of about 2,600 megawatts (MW), less than half of the contracted power level of about 5,800. As a result, DOE may be required to pay about \$30 million in demand charges for power contracted for but not taken.

DOE has taken several steps to negotiate lower base levels of purchased power and to be relieved of demand charges from its three power suppliers. Although it has been partially successful with two of these suppliers (Electric Energy, Inc., and Ohio Valley Electric Corporation), DOE has not been successful in obtaining relief from its major power supplier, the Tennessee Valley Authority (TVA). See Appendix A, Question 5.

DOE should alert the power suppliers of lower demand requirements and move forcefully and promptly to bring the power contracts more in line with the revised estimates of power needs. As a first step, DOE should obtain the best legal advice available to develop a case for renegotiating its power contracts. A complete picture of DOE's negotiating position should then be developed. DOE's contracts with TVA for electric power and for

enrichment services should be analyzed along with actual anticipated demand.* Other possible bargaining positions should be developed. DOE could offer to release TVA from its contracted demand in order to save TVA capital expenditures in building additional power plants in the late 1980s (TVA plans to install eight new electric power plants in this decade). Meanwhile in these next few years, DOE could attempt to assist TVA in wheeling excess electric power to other power pools such as Gulf States Utilities. To the extent feasible, DOE also could assist TVA in leveling its seasonal peak demand by taking more power in the spring and fall than in the winter and summer (this is already being done to a large extent).

DOE could also explore the possibility of not making payments for demand charges until the issue is brought before the Cabinet or the President for resolution in the best interests of the nation.

PROJECT STABILIZATION AGREEMENT FOR PORTSMOUTH

More than 30 construction contractors, including trade union and non-union contractors, will be involved in building the gas centrifuge enrichment plant (GCEP) at Portsmouth, Ohio. To date, labor relations experience at the GCEP site has been favorable. Work stoppages relating to contract expirations, strikes, and jurisdictional disputes have been minimal and handled well by Stone and Webster Engineering Corporation (SWEC). Local union agreements have been adopted with no significant problems. The layered structure of fixed-price subcontractors, fixed-price prime contractors, SWEC, and DOE has provided ample opportunity for the resolution of disputes. The project is progressing satisfactorily without a formal agreement.

Nevertheless, labor jurisdictional problems that could cause long and costly delays are likely to arise during construction. To avoid as many of these problems as

* As previously mentioned, the minimum operating levels of the diffusion plants should also be determined.

possible, negotiations have begun on a project stabilization agreement similar to ones used by NASA in the Apollo launch complex construction and the U.S. Air Force in the missile sites building program.

Establishment of this formalized working relationship with the Building and Construction Trades Department (BCTD) and each of the affiliated national and international unions is the responsibility of the SWEC in its contractual role as construction manager/constructor for the GCEP project. Stone and Webster formally initiated such negotiations with the BCTD in April 1979. We believe that this effort is important and should be rigorously pursued and completed as soon as possible.

GAS CENTRIFUGE CONSTRUCTION COMMITMENT

The review group observed that a decision was made in 1980 to slow the pace of the GCEP 1 year. The group also noted pressure from outside DOE to extend the GCEP project schedule further because of a lack of anticipated demand for enrichment services.

However, we believe several important factors justify completion of the first phase of the gas centrifuge project as quickly as practicable. More than \$500 million has already been spent on the project. Compared to gaseous diffusion, the substantial energy and cost saving of the gas centrifuge process offers economic advantages both for replacing gaseous diffusion capacity and providing additional capacity, if needed.

In addition, industrial contractors will be required to invest approximately \$250 million in manufacturing facilities to supply GCEP components. Continued slippage and project uncertainty could jeopardize this private-sector, capital-investment commitment. A major capital outlay for TVA may be avoided if a new electric power plant will not be needed to serve the enrichment program.

Furthermore, the technology of gas centrifuge is considerably more developed than the technologies of the four advanced isotope separation (AIS) processes, which have major problems in physics and engineering yet to be

solved. Finally, completion of the project will enhance the image of the United States as a reliable supplier of enrichment services and as a leader in technology development.

2

LONG-RANGE PLANNING

Integral to advising on long-range planning is developing an understanding of current enrichment enterprise strategy, parameters of the planning model presently used in establishing OURE strategy, and the opportunities afforded by probabilistic forecasting. In order to gain a sufficient grasp of this aspect of the enterprise, the review group requested data from DOE staff on specific areas (see Appendix A) such as:

- How OURE uses computer models in decision-making
- Synopses of computer models used with description of logic/methodology employed
- Eight detailed queries about the models
 - inputs
 - outputs
 - degree of confidence
 - validation process
 - accuracy in past performance
 - reaction to criticism about age
 - capacity limitations
 - model's independence in relation to other computer models.

RPA then carried out studies of the OURE strategy and models used in the long-range planning processes (see Appendixes B and C).

ENRICHMENT ENTERPRISE STRATEGY

Given the cost of operating enrichment plants and building new capacity, it is imperative that long-range options be

evaluated systematically and that sufficient management resources be available for this important task.

The review group observed a wide variety of planning activities involving different time frames and levels of management. They were impressed by short-term plant operations support and computer facilities and satisfied that all basic long-term planning functions are being carried out. OURE's planning system must, and does, treat all of the areas depicted in Exhibit 2.1:

- The prediction of domestic and foreign demand for enriched uranium
- Competitive analysis to estimate the U.S. market share
- SWU production system simulation to estimate the total annual cost of operation to meet demand with alternate facilities and technologies
- The setting of future prices to predict revenue and market share (insofar as the market is price-sensitive)
- Summary of financial results.

OURE recently prepared a program strategy to evaluate several technology deployment options (see Appendix C). The report is based on three planning studies analyzing complementary enrichment enterprise issues. The results are evaluated along with other relevant considerations to provide input for enrichment strategy determination.

The basic issues addressed in the strategy document are:

1. Development and evaluation of alternative multiplant (gaseous diffusion and centrifuge) 15-year operating plans, mainly as a basis for decisions required in the early 1980s
2. Evaluation of long-range minimum-cost alternative strategies, involving advanced processes and projection of impacts of various advanced gas centrifuge/advanced isotope separation (AGC/AIS) deployment scenarios
3. Consideration of economics and other factors involved in replacing existing gaseous diffusion plant (GDP) capacity with GCEP capacity, and the sensitivity of the economics to power cost changes, centrifuge improvements, etc.

Exhibit 2.1
Enrichment Enterprise Planning System

ENRICHED URANIUM DEMAND MODEL

Several scenarios were projected (each with a 30-year, minimum cost operating plan) that use existing diffusion, centrifuge, advanced centrifuge, and AIS in varying combinations. The requirements of the various scenarios with regard to feed, power, costs, and other factors were calculated and compared.

Five operating plans through 1995 were developed and evaluated that provided an array in which (to varying degrees) increased flexibility, customer assurance of availability, competitive position, and other objectives are obtained at the cost of a temporarily greater negative cash flow to the government.

On the basis of this analysis, a plan was selected that provides for operation of the GDPs at reduced power levels in FY 1982, 1983, and 1984 with production of 14.1, 16.3, and 20.7 million SWU in those years, respectively. Of the five options considered, this strategy results in the lowest price, a favorable impact on the U.S. supplier image, a favorable 1982 budget impact, and maximum flexibility to respond to increased demands or unexpected production losses.

Since these advantages are obtained at the cost of incurring one of the higher negative cash flows to the government, flexibility was retained to shift to an alternative plan whose course is identical over the next several years or to some intermediate plan if that becomes preferable. The advantage of the alternative plan is that of all the plans considered it results in the most favorable cash flow for the government. The key drawbacks of the alternative are that it results in a higher SWU price to the customer (a problem with potential cost and political acceptability if a substantial portion of the fixed costs for contract power cannot be renegotiated) and reduced flexibility to accommodate increases in demand and unexpected losses in production.

OURE's strategy document describes an important and well-done first step in instituting the process of long-range planning. It identifies the decisions that must be addressed in deriving the appropriate near-term and long-term deployment of enrichment technologies; the variables affecting decisions are identified and the decision milestones for the selection of the appropriate technologies are established.

The strategy document should be regularly reviewed and updated. Further steps should be taken to refine the techniques and assumptions on which it is based. At present OURE can devote only a limited amount of staff time to this activity because of budgeting and manpower restrictions. Nevertheless, OURE has a special need for a quick-response, non-labor-intensive planning support system that will enable it to respond to the various needs of upper management in DOE and Congress.

PROBABILISTIC FORECASTING

Because estimates of SWU demand can drive enrichment capacity requirements, demand prediction is central to enrichment enterprise business strategy. With the design and construction of new capacity taking more than 10 years, long-range demand forecasts must be realistic. OURE's forecast, based on signed contracts, is reasonably firm for the next 5 years, but subject to increasing uncertainty thereafter. This uncertainty must be dealt with decisively since power and capacity contract decisions require 8- to 10-year lead times.

OURE devotes approximately 6 person-weeks twice a year to a reactor-by-reactor demand forecast using a wide variety of information sources that the review group considers valid. These sources include:

- Other forecasts (ORO, EIA, NAC)
- Construction progress reports
- Licensing status reports
- Utility plans
- Cable traffic and marketing missions
- Outside and top management reviews.

While valuable, this level of effort is not sufficient for such a vital task. Additional resources would improve OURE's ability to gather more information and update its data on a regular basis.

At present, point estimates are made for startup dates, customer inventory policies, and cancellations. Competitive analysis is incorporated in "yes or no" judgments of DOE contract potential. Such estimates, however, could be significantly improved by the use of probabilistic techniques.

The OURE planning group provides three point estimate forecasts: low, medium, and high. The high represents the highest possible demand; the medium estimate represents the expected level of demand; the low estimate, however, is somewhat higher than the lowest foreseeable demand. Therefore, the assumptions made in the lower case are not analogous to the assumptions made for the medium and high cases.

For example, 250 GWe to 350 GWe is the current planning estimate for nuclear power generating capacity to be supplied by OURE in the year 2000. OURE is currently under contract to supply enrichment services for generating stations that total over 300 GWe by 2000. However, nuclear power plant schedules continue to slip; and foreign competition to provide enrichment services is increasing, which may cause a significant amount of contracted separative work to be postponed or cancelled. Demand scenarios of less than 250 GWe (225 GWe or 200 GWe) as a lower bound are plausible and should be considered. The high estimate (350 GWe) is appropriate as an upper bound.

The use of probability judgments by OURE would provide a demand forecast range with confidence limits. Forecasting in the private sector often involves the application of probabilistic density functions for each dependent variable. Their cumulative expression results in a range for market demand within confidence limits that enhances the development of contingency plans able to cover a wide range of possibilities. Adopting this probabilistic approach would produce an improved forecast that could be used in policy studies involving risk analyses.

PARAMETERS OF CURRENT PLANNING MODEL

The recently initiated program strategy effort described above had to rely on existing planning models for its

analytical base. In addition to other models, a production costing model was used to analyze several technology deployment options. See Appendix A (Questions 14-16).

In preparing its strategy study, OURE modified its EDIC (Equal Discounted Incremental Costs) model. This model is designed to simulate the enrichment complex with suitable economic criteria incorporated to develop economically optimum modes of operation with various optional input constraints. EDIC is not designed to provide absolute results. Rather, through a series of sensitivity analyses over a plausible range of input assumptions, trends useful to decision-making can be identified.

Input to the EDIC model includes cost and performance data on existing and new plants, tails assay levels, cost escalators and various special constraints. Output of the model includes a summary of operating plan parameters (power levels, tails assay, and feeds), costs by category, total annual costs, and expense of the total campaign.

The objective is to obtain enriched uranium at minimum cost taking into account the expense both of feed and separative work. Specifically, the goal is to minimize the present value of the combined controllable costs of DOE and its toll enrichment customers, referred to as TEC (Total Enterprise Cost).

The principal tradeoffs to which the EDIC criterion of minimum cost applies are feed versus separative work and production versus time. Thus the marginal cost relationships to which the optimizing criterion applies are specifically derived for the variables of uranium enrichment.

During the time when factors such as enriched uranium demand, power costs, and technologies were relatively predictable, the model served its purpose well. Now OURE must adjust to an increasingly competitive and unpredictable marketplace in which strategic long-term planning is essential.

Built in 1964 to facilitate the transfer of the uranium enrichment enterprise from military to civilian uses and to solve for the "least cost" method of operating a set of facilities to meet a specified enriched uranium demand over a 30-year period, EDIC was not designed to develop and analyze long-range strategic options nor to deal with..

technologies other than gaseous diffusion. Adapting EDIC to strategy purposes required both modification of the model and considerable manual adjustments.

Like many facility production codes, EDIC is a sizable program demanding a large share of the computer and a great deal of computer time. The size and manual intervention characteristics of EDIC need a long response time for the planning systems, which limits OURE's ability to investigate a broad spectrum of technology deployment options and contingencies. But the chief drawback of EDIC is that it was designed as a deterministic, "perfect foresight" model with no allowance for risk. EDIC model cases and the analyses drawn from them understate the costs of excess capacity as well as the costs of under-investment. Difficult to interpret, the model is an inappropriate guide for policymakers.

A new planning systems's fundamental functions should be (1) to formulate alternative strategies (how changes in facilities and technologies affect timing or pricing actions) and (2) to predict the effect on the result measures of pursuing each strategy. Recognizing that many factors are uncertain and outside of OURE's control, the system would explore the broad range of possible outcomes and give decision makers a clear picture of the risks each strategy entails.

Assigned likelihoods (however subjective, for DOE contract potential), future online dates, and reactor cancellations are more accurate than point and "yes or no" estimates, which correspond to probabilities of zero or one. Probabilistic forecasts would provide clearer visibility of the possible range of demand to outsiders and management and also permit formal risk analyses of the results of over- or under-capacity.

The entire system should be based on well-defined decision focuses and result measures. It should be inexpensive enough to run repeatedly in order to function as an effective management tool. A simple analog of the EDIC model could be developed to evaluate strategies that include some level of uncertainty. The continued development and refinement of the enrichment program's strategy could be improved by a model specifically designed for long-range planning purposes.

The elements and functions of such a strategic planning model are discussed in Appendix C along with suggestions for its building and implementation.

3

MARKETING OF ENRICHMENT SERVICES

With increasing revenues and an inventory of more than \$1 billion, OURE resembles a private enterprise that markets uranium enrichment services worldwide. While the domestic market is primarily captive, in the international market OURE faces mounting competition from the USSR and from two European consortia, URENCO and EURODIF. In a period of declining cost for providing enrichment services, maximizing foreign market share has been consistent with OURE's goal of providing enrichment services at the lowest possible cost. In addition, foreign market share is important to U.S. foreign policy objectives. See the attached chart for power growth projections through 1995 (Exhibit 3.1). Competition from European suppliers is increasing and can be expected to continue. Countries such as Japan, Australia, and Brazil also may enter the market as new suppliers. See attached table for the world market supply (Exhibit 3.2).

Since the international market is subject to increasing competition and uncertainty, planning for incremental capacity additions to supply foreign demand becomes even more difficult. Therefore, in planning for new enrichment capacity, it is essential to understand and allow for the factors that affect the U.S. share of the foreign market.

FACTORS IN FOREIGN MARKET SHARE

During the early 1970s many countries became concerned about relying on a single source for their enrichment requirements. France, Germany, and Italy entered into supply contracts with the Soviet Union that remain in effect today. Also, the United Kingdom, the Netherlands, and Germany entered into discussions that led to formation of the URENCO consortium, and France announced its

Exhibit 3.1

OURE June 1980 Civilian Nuclear Power
Growth Projections in Gigawatts

	1985			1990			1995		
	High	Mid	Low	High	Mid	Low	High	Mid	Low
Total	162.0	144.8	130.7	228.2	197.0	182.7	283.7	260.4	224.6
USA*	104.5	95.7	84.9	140.3	129.0	124.8	164.9	155.4	141.6
Foreign Market	57.5	49.1	45.8	87.9	68.0	57.9	118.8	105.0	83.0

* Requires enrichment contract prior to 1995.

SOURCE: Strategy Document, DOE, September 1980.

Exhibit 3.2

**Uranium Enrichment Capacity Plans
(Millions of SWU Per Year)**

	1980	1985	1990
United States	25.8	27.3	30.6
EURODIF	6.3	10.8	10.8
URENCO	0.6	2.0	3.0
U.S.S.R.	3.0	3.0	3.0
Japan	—	—	1.0
S. Africa	—	0.25	0.25
Brazil	—	0.25	0.25

SOURCE: OURE, DOE, 8-6-80.

decision to construct a commercial enrichment facility with multi-national ownership -- EURODIF. Concern over relying on a single source for energy supplies was reinforced by the Arab oil embargo in 1973.

In addition, as countries began ventures to diversify sources of enrichment services, the United States took a number of actions that brought U.S. reliability as a supplier of enrichment services into question. First, in January 1973 the United States announced a major change in the terms of future U.S. enrichment contracts: this switch from a requirements to a long-term, fixed commitment contract made the contract significantly less attractive to both U.S. and foreign customers. The rationale for switching to the new terms was to firm up the future demand for U.S. enrichment services and also to establish a contract containing the type of terms that would be practical for creation of a private enrichment industry in the United States.

While the new contract terms were applied uniformly to both domestic and foreign customers, from a foreign customer's viewpoint the switch to less attractive conditions demonstrated that the United States could unilaterally change the terms and conditions governing the primary source of enrichment services. Also, the suspension of long-term contracting for 9 months during 1972-73 added to a growing picture of the United States as a unilateral/unreliable supplier.

After intensive analysis, in September 1973 the United States announced the adoption of long-term fixed commitment contracts that unfortunately coincided with the Arab oil embargo. As a result of the embargo, domestic and foreign orders for nuclear power plants and enrichment services soared. By July 1974 the contractual commitments reached production capacity, and a month later the United States closed the order books and announced that no new applications for enrichment services could be accepted until additional enrichment capacity could be obtained. The suspension lasted almost 4 years, during which time foreign enrichment suppliers emerged and began establishing a solid position among non-U.S. customers.

Meanwhile in 1975 a delay in issuing uranium fuel export licenses further eroded U.S. credibility with the foreign market. In 1975, the AEC was split into the Energy

Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). Although never given any clearly defined legal role or authority, the NRC became responsible for licensing exports including enriched uranium. Generally, the NRC took much longer than its predecessor agency to process nuclear export license requests (partly because it had to work out licensing procedures with other federal agencies and partly because congressional and public concern over nuclear proliferation issues was heightened by India's 1974 peaceful nuclear explosion). The slowdown that resulted in granting licenses contributed to less foreign market confidence in the United States as a supplier of enrichment services.

In July 1978 the United States reentered the foreign enrichment market. It replaced the long-term, fixed-commitment contract with the adjustable fixed-commitment contract to provide the customer with greater scheduling flexibility.

However, today not only is U.S. reliability a major factor in determining foreign market share but also the emergence of non-U.S. suppliers has dramatically changed the composition of the international enrichment market. Many countries have adopted "produce at home" policies in an attempt to improve their national security, a significant incentive for new entrants into the market for uranium enrichment services.

Although the United States is still the major supplier of uranium enrichment services in the free world and provides enrichment services at a very competitive price, foreign enrichers have obtained and, by all indications, will continue to obtain an increasing portion of the enrichment market once dominated by the United States. Records show that as recently as 1979 the United States supplied about 50 percent of non-U.S. enriched uranium needs. But DOE expects that the U.S. share will decrease to 32 percent of the total deliveries in 1990.

By the mid-1980s foreign enrichment capacity could, if current plans materialize, satisfy all foreign enrichment service needs currently under contract to DOE.

Although it is unlikely that DOE will lose all its foreign contracts, the availability of alternative sources represents the beginning of a new era in which the monopoly

the United States once had is quickly diminishing. These uncontrollable factors will continue to be important in determining foreign market share. Therefore, American success in foreign markets will depend upon increased sophistication in assessing and monitoring regional economic and political developments and competitors.

ANALYSIS OF COMPETITION

From our viewpoint, OURE currently performs a competent, reasonably in-depth market analysis on a country-by-country basis monitoring economic and political developments, nuclear energy policies, and balance of trade performance and identifying both key decision makers within a foreign market and the criteria used in decisions to procure enrichment services. This analysis helps OURE assess customer needs, identifies high-potential target markets, and provides input to demand forecasts.

In addition to market analysis, OURE also studies its existing competitors using information from both customers and suppliers. But, in the present approach, OURE does not appear to consider adequately the dynamics of the enrichment services market, a market until recently monopolized by the United States. Now that foreign clients have the opportunity to turn away from the United States either to develop domestic capacity or to deal with other trading partners, the domestic foreign market share may well continue to diminish. OURE should monitor both individual and collective strategies in order to halt the erosion of the foreign market size. At this time, the analysis of competition by OURE is not as sophisticated, well-developed, sharply focused, and comprehensive as the analysis a private industry might perform.

In order to assess the foreign market in terms of the makeup of U.S. competition for enrichment services, OURE must do two things successfully. First it should continue to perform total foreign market demand forecasts. Secondly, it must develop a more effective means of estimating the U.S. share of this total market in order to appreciate and deal successfully with the dynamics of the foreign enrichment supply and demand. The nature and

intensity of competition and relative market share depend on the interaction of five forces:

- Bargaining power of buyers (e.g., utilities)
- Bargaining power of suppliers (e.g., uranium companies, suppliers of electricity to enrichment plants)
- Threat of substitute product or services (not currently significant)
- Threat of new entrants (e.g., Japan and Australia)
- Rivalry among existing firms (e.g., EURODIF, URENCO).

Through the use of nuclear reactor forecasts and observation of customer needs (e.g., price, preferences, political requirements), OURE has developed an appreciation of the bargaining power of key buyers. Of the other four major forces, the two most significant are the threat posed by new suppliers and the nature of the rivalry among existing competitors.

OURE would benefit from a clearer understanding of existing and potential competitors in two ways:

- To quantify uncertainty in estimating the domestic share of the foreign market would provide more accurate probabilistic data for the proposed demand forecasting model.
- To analyze American strengths/weaknesses, competitor strategies, and customer preferences would enable OURE to modify its own approach in order to gain the maximum competitive advantage.

We have developed a framework to enable OURE to analyze foreign competition realistically through profiles both of existing organizations and potential suppliers of enrichment services. The analysis, described in detail in Appendix D, has three components:

- Diagnosis of competitors' future goals and strategies
- Identification of assumptions held by competitor
- Identification of particular strengths and weaknesses.

We then discuss the interrelationship of these components in order to show how the profile can be used:

- To assess likely U.S. market share
- To modify current U.S. strategy.

In the appendix ("An Approach to Assessing Foreign Enrichment Requirements") we also discuss the need to develop a competitor intelligence system in order to comprehend the dynamics of the market realistically. Such a system is essential to assure OURE that the large quantities of data needed for sensitive competitive analysis are collected properly and in a timely, efficient manner.

OURE MARKETING RESOURCES

At present the marketing staff at OURE consists of three people with plans for additional personnel if two overseas marketing offices are opened. Marketing duties include the following activities as outlined by OURE:

- Evaluating and implementing potential marketing improvements
- Obtaining marketing support services
- Evaluating competitiveness of enrichment contract terms and conditions
- Performing detailed market surveys, target market analyses, and periodic updating of target markets
- Carrying out promotional activities
- Conducting marketing missions.

Besides handling marketing activities these staff members often also have other duties. So far the office has supplemented the small staff with additional outside help:

- Consultants to perform world market surveys and other specialized studies
- Oak Ridge Operations personnel to make contracting and marketing analyses as well as to travel with the OURE team on marketing missions
- Information exchange with the Department of State and DOE's Office of International Affairs to keep... informed of potential market opportunities.

Despite this assistance and despite achievements in attracting customers, the small staff size has hampered the ability of OURE to keep pace with the demands of a shifting international market. As we have already noted, the marketing staff needs to develop a more sophisticated method of assessing the nature and intensity of foreign competition for clients. This challenge dictates the need for more specialized skills to solve the problems posed by uncertain market demand.

Under the constraints dictated by the small staff, OURE does not attempt to perform completely independent nuclear power growth forecasts based on electrical growth projections. In the words of a staff member asked about marketing,

We limit our effort to looking at currently available information regarding the status of nuclear projects and, where applicable, correlate those findings with lead-times developed by others such as the Nuclear Regulatory Commission. We use information obtained by marketing staff through their monitoring of cables and participation in marketing missions. Originally, it was proposed to staff overseas offices (Tokyo, Brussels, and others), for monitoring market activities as well as servicing our current non-U.S. contracts.

We try to weigh outside analysis for reactor projects that have not started construction or have financial/load growth/regulatory problems that are not readily obvious. We utilize the expertise of sales support personnel at Oak Ridge to provide feedback concerning our estimates and make adjustments when appropriate. We have a review process within OURE that allows several people to examine and question the final projections on a reactor-by-reactor basis.

Of necessity, the director of OURE heads most marketing missions, thus reducing the time he has available for overall guidance of the program. He makes an average of two overseas trips annually with each mission lasting 3-4 weeks. He cannot delegate an emissary on marketing trips to the Far East where it is customary for high-level officials to lead major marketing endeavors.

For such a small staff, the three employees assigned to marketing have accomplished much during the 1980 fiscal year:

- Completed marketing missions to Japan, South Korea, Taiwan, Egypt, Greece, Turkey, Canada, Mexico
- Held enrichment seminars in five U.S. cities in February 1980
- Put out a news publication in March 1980 with another issue being prepared now
- Assisted in gaining acceptance of relaxations in export policy
 - Single export license can now cover 5 years of enriched uranium deliveries
 - License for routine reload need not be reviewed by State, Commerce, Defense, and Energy, but can be issued by the NRC alone
- Procured, set up, and manned a booth publicizing DOE enrichment capabilities at two national nuclear trade fairs.

Since factors adversely affecting marketing of enrichment services have created an enduring negative attitude by customers (in particular, the switch to a less attractive enrichment contract in 1973, the 4-year closing of the order books, and the delays in granting export licenses), OURE should commit more of its resources to strengthening this crucial aspect of its overall program.

Unlike the current OURE approach, a private business would assign regional marketing representatives broad responsibilities that might include:

- Maintaining high-level customer contacts
- Providing up-to-date information on regional economic and political developments
- Monitoring competitive activities.

A private business also would reserve the efforts of top management for planning critical marketing objectives but not devoting large amounts of work time to actual implementation. This would be handled by marketing specialists.

ENRICHMENT SERVICES CONTRACTS

Although the contracts offered by OURE for enrichment services may seem outside the scope of marketing, beginning in 1973 the United States announced a major change in the terms of future U.S. enrichment contracts that made the contracts significantly less attractive to foreign customers and, thus, became a factor in marketing domestic services.

The original long-term enrichment contract offered by the United States was known as a requirements contract. Under this contract the United States agreed to supply all of the enrichment services required to fuel a specific nuclear reactor for up to 30 years. The customer had to provide the United States a yearly estimate of its enrichment requirements for the next 5-year period. The estimate was nonbinding, and customers could demand delivery of additional enriched uranium upon giving only a 180-day notice to the United States. The requirements contract favored the customer by offering flexible terms that permitted a customer to match fuel needs with contractual enrichment requirements.

The contract introduced in 1973 is known as the long-term, fixed-commitment contract and differs from the requirements contract in that it requires the customer:

- To contract for fixed quantities of enrichment services on a take-or-pay basis for an initial 10-year period
- To enter into the contract 8 years before the first delivery is called for
- To make an advance payment.

The rationale for switching to the new contract was to firm up the future demand for U.S. enrichment services and also to establish a contract containing the type of terms that would be practical for creating a private enrichment industry in the United States.

While the new contract terms were applied uniformly to both domestic and foreign customers, from a foreign customer's viewpoint the switch to less attractive conditions demonstrated that the United States could unilaterally change the terms and conditions governing the primary source of future enrichment services.

The United States announced the adoption of long-term fixed commitment contracts in September 1973, which coincided with the Arab oil embargo. Soon after domestic and foreign orders for nuclear power plants and the associated enrichment services increased. By July 1974 the contractual commitments reached production capacity, and a month later the United States closed its books and announced that no new applications for enrichment services would be accepted until additional capacity was available. In July 1978, when the United States reentered the market, OURE replaced the long-term, fixed-commitment contract with the adjustable, fixed-commitment contract to allow greater scheduling flexibility.

From our examination of the contractual restraints imposed on enrichment services, it is evident that although OURE has several basic contract terms (pay plans, length of contract) that are more favorable than those offered by competitors, OURE has little flexibility to negotiate. All new contracts must offer the same prices and terms to every customer, regardless of volume. This inability to negotiate prices has hindered international marketing, particularly in view of the flexibility in competitor contracting. For example, while the U.S. SWU price is significantly lower than standard prices charged by competitors, one competitor has recently offered to meet OURE's price for selected customers.

If OURE were run more like a private enterprise, greater flexibility in contract terms, prices, discounts, or duration of commitment would be standard.

Examples of contracting inflexibility are provided below:

- OURE's contract terms and pricing cannot by law be confidential to the two parties.
- OURE's customers are forced to sign a nonproliferation agreement to be eligible as customers for enrichment services.
- OURE is unable to offer package deals including reactor financing or other services while competitors can.

Therefore, the flexible terms and conditions available in this contract are offset by the non-negotiable criteria set by law in regard to SWU pricing. Until this weakness

is remedied, marketing U.S. enrichment services will continue to operate under a major handicap.

CONTRACT CANCELLATION CHARGES

During our discussions and meetings during the past 4 months, we have not been able to identify the way cancellation charges are developed. If the present charges were higher, they could be a significant factor in marketing by acting to discourage clients from cancelling contracts. In addition, higher cancellation charges would help OURE in planning for new capacity by increasing the certainty of fulfilling contracts.

The government-owned enrichment program runs on cost-recovery principles that are very different from the goals motivating a profit-driven enterprise. Because the Department of Energy is prevented by law from recovering more than costs incurred by contract cancellations, OURE staff explains the figure in the context of marketing: "Cancellation terms are based upon detailed cost analyses, and are computed on the principle that DOE must recover costs which may arise as a result of any contract termination. These costs are borne by the customer who terminates (i.e., not shared by the remaining customers who do not terminate)."

Since December 15, 1978, termination charges have been based on SWUs terminated as a percentage of applicable enriching services charge, as set by established charges in effect on the date of receipt of notice of cancellation.

It is our understanding that the termination charges of the competitors are much higher than DOE's. Several episodes have apparently occurred in which foreign utilities cancelled lower cost SWUs from DOE rather than from DOE's competitors. This occurred because it was the most economical way to avoid excessive enrichment commitments. Private business could and perhaps would take steps OURE is prevented by law from doing, which would eliminate this discrepancy that encourages cancellation of DOE contracts when a customer has overcommitted its enrichment needs.

The dichotomy posed by cost-recovery versus profit-motivated enterprises is as evident in the cancellation charges as it is in SWU pricing, a dilemma faced by OURE but not shared by private business. To maintain effective business practices, OURE must justify cancellation terms through such practices as cost analysis to insure that its cancellation charges are, in fact, recovering the cost incurred.

By late 1980 OURE issued a new table of termination charges. The new, higher rates have been calculated to recover costs incurred when enrichment contracts are cancelled.

4

FINANCIAL MANAGEMENT

Sound financial management is fundamental to the success of any business operation. Since OURE must obtain an annual congressional budget authorization, its financial management differs markedly from that of a private business. In calculating expected revenues and costs, OURE often must operate under short-term, budget-related constraints. In general, a private business (even if it were part of a large corporation) has more authority over financing its operations.

In order to assess the efficacy of OURE fiscal practices, the review group focused on current funding and budgeting procedures for the uranium enrichment enterprise, then examined factors used in establishing SWU pricing. Next it analyzed the role a rolling period to estimate costs and pricing of the enterprise might play. Finally, the group assessed the internal auditing organization and procedures employed by OURE.

OURE FUNDING AND BUDGETING

As in a private corporation, the OURE capital investment decisions require a long-term planning horizon in which short-term cash flow objectives are traded off against long-term market and cost-related objectives. Under the current funding process that requires annual budget review within the Administration and authorization from Congress, often OURE is forced to give higher priority to short-term budget-related objectives. This sometimes results in less than optimal decisions for capacity additions as well as for operations.

A revolving fund, such as that proposed by Congressman Manuel Lujan of New Mexico in H.R. 6992, is a way of insulating OURE from short-term budget influences. A revolving fund is a fund established for making loans,

payments, and the like, which is regularly replenished from repayments. In the federal budget, Public Enterprise Funds are similarly designated to finance a cycle of business-type operations in which outlays generate collections, primarily from the public. The Colorado River Basin River Project, Alaska Hydroelectric, and the Bonneville Power Authority are examples of public enterprises financed in whole or in part by revolving funds.

The uranium enrichment enterprise also acts as a public program in that it provides a service which receives revenue for value added to goods used. Furthermore, the program's suppliers and customers are both in the private sector.

If enacted, the uranium enrichment fund would operate in the following way:

The Secretary of Energy issues bonds and sells them at appropriate rates and maturities to the Secretary of Treasury (who may resell them). Proceeds from the bond issue and unexpended appropriations are used to finance expenditures. Congress may also make new appropriations to the fund.

The Secretary of Energy is authorized to make expenditures from the fund which are included in the annual budget submitted to Congress by the President without further appropriation and fiscal year limitations. These expenditures include operating, R&D and capital costs, and payments of interest and principal on bonds.

Expenditures, however, are subject to certain limitations and directives, which may be included in authorization and appropriation acts. The Secretary of Energy could not acquire plant and operating equipment, the cost of which exceeds 5 percent of the total net book value of uranium enrichment fixed assets or construct new enrichment capacity without express congressional authorization. In addition, obligations for plant and capital activity that would increase expenditures for the capital activity budget to a level greater than 15 percent above that approved by Congress could not be made until Congress had been notified and a period of 30 days while Congress is in session had elapsed.

Principal and interest on bonds are payable from net proceeds -- gross receipts less operating and R&D costs.

Revenues and return on investment of funds balance plus operating reserves (if any) constitute the gross receipts of the fund. Revenues generated include all receipts, collections, and recoveries derived from the provision of services and the production and sale of enriched uranium. If the amount of money in the fund is considered to be in excess of current needs, the unused balance may be invested in obligations of the United States, creating a return on fund balance.

Under these circumstances, OURE could be managed as a self-sufficient entity, generating adequate cash flows for its operation and capital outlays with an exceptionally strong borrowing base should bond financing become necessary for major capital expansion projects. In this mode, OURE could achieve financial flexibility in matters such as timing of purchases vis-a-vis receipts, managing cash, and other cost-saving techniques employed by corporate management.

Besides these advantages, the revolving fund would give the program greater visibility and credibility among U.S. taxpayers. With figures presented on an actual basis, OURE's performance would be measured with more meaning than is possible using the current hypothetical case. It would become evident that OURE is a self-sufficient enterprise, which can operate on its own.

The operation of the fund is summarized in the following diagram (Exhibit 4.1).

SWU PRICING

Legislation stipulates that the U.S. price for SWU be consistent with full-cost recovery over a reasonable period. However, since the legislation does not specify how SWU price is to be determined, OURE has fairly wide flexibility in setting the price while still adhering to the cost-recovery requirements. Appendix E describes in detail OURE's procedures for setting the price for separative work.

OURE has recently developed a computer program that estimates future annual enrichment costs and SWU sales.

Exhibit 4.1
START-UP

SOURCE: HR 6992 April 1, 1980.

A SWU price is then computed so that the expected net cumulative profit is zero over a 10-year period. The accounting principles used in the computer model are the same as those used by DOE in developing annual financial accounts for OURE.

In addition to estimates of future costs and unit sales, OURE's cumulative profit to date is also considered in setting a SWU price for the following year. A cumulative profit is treated as a credit (and a cumulative loss as a debit) in determining the next year's price. The computer model repeats the procedure for several subsequent years and arrives at a time series of expected SWU prices based on current projections of costs and SWU sales.

In terms of overall importance, however, price appears to be a secondary consideration in the foreign market for SWU; the reliability of the supplier is of prime importance. If the American reputation as a reliable supplier is tarnished, then the current low price per SWU (\$110 versus the competitors' \$170) constitutes an important market advantage. But if perceived to be a reliable supplier, the United States could conceivably raise its world market share. The United States might even be able to justify charging a higher price to foreign customers because of the greater uncertainty associated with their requirements and the potential costs of excess capacity.

ROLLING PERIOD TO ESTIMATE COSTS AND PRICING

A financial analysis model is used to determine the annual and 10-year average production unit costs. A 10-year rolling period has been established as a reasonable length of time since it is long enough to smooth out annual variations but short enough to have some assurance of recovering the costs (in constant dollars). Costs associated with each annual production schedule, determined by the uranium enrichment planning model, are summed for 10 years. Interest on the government's investment and the overhead costs for 10 years are added to the direct production cost. The sum of these three cost components is divided by the sum of the separative work sales for the 10-year period plus the inventory of low-enriched

Exhibit 4.2
SWU Pricing Forecasts for
1, 3, 5, 10, and 15 Year Rolling Periods

SOURCE: Resource Planning Associates, Inc.

Exhibit 4.3
Contract Audit Within ORO Complex

SOURCE: ORO, Department of Energy, 8-80.

uranium at the end of the 10-year production period. Appropriate provision is made for the time-value of money in treating the projected revenues. The resultant quotient is the SWU unit price for the 10-year period. The financial model calculates the annual 10-year rolling unit price for the 15-year production planning period used in the production planning model.

A sensitivity analysis done by OURE shows that the computed costs per SWU are insensitive to the cost recovery period if the latter is more than 3 years. At the same time a cost-recovery period greater than 3 years is needed to provide some stability in pricing (see Exhibit 4.2).

The choice of a 10-year rolling period for cost recovery is, thus, a reasonable one and serves the purpose as well as a 5- or 15-year recovery period.

AUDITING PROCEDURES

The procedure and personnel currently used to audit the enrichment enterprise appear adequate and consistent with internal audits used in private business. The internal audits are performed according to General Accounting Office (GAO) standards by the Office of Performance Evaluation, which reports directly to the manager of Oak Ridge Operations (ORO). There are 17 auditors on the ORO staff. Seven are certified internal auditors. The organization of the contract auditing staff within the Oak Ridge complex is depicted in Exhibit 4.3.

The responsibilities of the auditing staff are:

- Financial and administrative review of major cost-type contractors
- Management and operational audits examining program results and efficiency
- Annual CPA certification of the Uranium Enrichment Service's Activity (UESA) financial statements
- Team reviews of selected areas with ORO personnel

- Evaluation of contractor audit organization, staff and activities
- Management of audit program with DCAA and HEW.

Projected costs are presented in the program plan prior to the start of the fiscal year. These projected costs serve as a baseline to monitor program progress and, along with other information, are reported to the Assistant Secretary for Resource Applications on a monthly basis. Potential problem areas can thus be identified and remedial action proposed.

In addition to internal audits, GAO has overall responsibility for federal procurement. However, an outside audit could lend additional credibility to the enterprise in the eyes of its customers. In addition, if an outside audit were instituted, this could help the passage of the resolving fund legislation by assuaging any worries about financial mismanagement that opponents of the bill might have.

5

RESEARCH AND DEVELOPMENT

DOE will spend several hundred million dollars on research and development of new enrichment technologies over the next two decades. Five major technology options are currently being explored: advanced gas centrifuge (sets IV, V, and VI) and four advanced isotope separation processes (two atomic vapor laser isotope separation processes, molecular laser isotope separation, and plasma isotope separation).

Because advanced centrifuge technology has been developed more fully than advanced isotope separation technology, more is known about its commercial capability and related costs. Gas centrifuge machines will use 95 percent less electricity than the gaseous diffusion process. DOE also estimates that the advanced machines will produce separative work at about 33 (Set IV) to 50 percent (Set VI) less cost than the centrifuge machines now scheduled to be installed at Portsmouth. While projections of SWU production costs for the advanced isotope separation processes are about 50 percent lower than for the set IV advanced gas centrifuge, they are about the same for Set V and VI machines, which can be retrofitted into the Gas Centrifuge Enrichment Plant. It should also be noted that because of the many uncertainties associated with an emerging technology such as advanced isotope separation, cost projections may be unreliable and actual costs may be very much higher.

All the development programs are funded from current enrichment service revenues, but are managed separately. OURE, under the Assistant Secretary for Resource Applications, directs the advanced gas centrifuge program, while the Assistant Secretary for Nuclear Energy is responsible for directing work on the advanced isotope separation processes. About \$65 million per year is budgeted in fiscal year 1981 for all centrifuge development. While about \$80 million per year has been budgeted for advanced isotope separation projects, that amount is expected to

increase significantly. In total, research and development comprises 12-15 percent of the annual enrichment program expenditures.

We considered the management-related implications of parallel research and development on both types of processes, but did not specifically evaluate the content of advanced isotope programs.

IMPORTANCE OF ADVANCED CENTRIFUGE TECHNOLOGY IN THE GAS CENTRIFUGE PROJECT (GCEP)

The baseline gas centrifuge technology to be developed in the Portsmouth GCEP is being developed, and demonstrated operation of the first process building is expected to be achieved in 1988. This technology will be used in the first two of eight process buildings.

In addition, several hundred million dollars of the centrifuge development budget are allocated for the development of advanced centrifuge systems. Improvements in gas centrifuge technology, which primarily are extrapolations of existing technology rather than fundamental research, offer the promise of up to 50 percent performance increase and about 33 percent cost improvement more than the first-generation centrifuge machines now planned for installation. Advanced centrifuges are being developed for installation in the GCEP process buildings after building number 2, for replacement of machines in buildings 1 and 2, and for incorporation into any centrifuge enrichment plants subsequent to GCEP. The first-generation Advanced Machine Development program is expected to be completed between 1987 and 1989. The timing is significant because if power costs continue to escalate at a rate greater than the inflation rate, the need to replace diffusion capacity with a less costly process will be desirable at that time.

DIVISION OF MANAGEMENT FOR ADVANCED
ISOTOPE SEPARATION (AIS) DEVELOPMENT
FROM REMAINING ENTERPRISE

Technical and program direction of the development of three AIS processes is not the responsibility of OURE, but of another departmental organization (Nuclear Energy). Nevertheless, the costs for this development program are recovered in enrichment service revenues and, if the technology is implemented, will become part of the enrichment enterprise.

The separation of technological development responsibility from funding responsibility in this project may be causing costly delays. For example, the 1986 target date for initiating full-scale development test and evaluation of limited AIS production may be further in the future and consequently more expensive than a research program funded by a private business enterprise. A delay in any of the decisions affecting technology selection will result in increased program costs.

In a private business a single organization is usually given authority for the development of all technologies of interest to a particular program. Authority is centralized in a single department to assure informed decision making.

The current split of advanced enrichment technology research and development responsibility between two Assistant Secretaries may delay the selection of one of the advanced isotope separation technologies -- and later between advanced gas centrifuge and advanced isotope separation processes. Because a delay in any of the decisions affecting technology selection will increase program costs, we believe that OURE should be granted authority over both the advanced gas centrifuge and advanced isotope separation technologies.

6

GENERAL MANAGEMENT

OURE is being managed well; however, the review group focused on three areas for analysis and possible modification in policy or practice:

- Clarity of Overall Objectives
- Communication between OURE and DOE
- Level of Fiscal and Managerial Autonomy.

These aspects of the general management of the enrichment enterprise reflect problems caused perhaps by the unique characteristics of a revenue-producing division of a governmental department.

CLARITY OF OVERALL OBJECTIVES

Consistent management objectives are critical to the success of any organization. Although each level of the OURE organization has operational objectives, no "corporate" objectives have been established or endorsed by DOE. OURE should develop overall objectives jointly with upper level management.

Since the review group's report to the Assistant Secretary for Resource Applications was submitted on December 2, 1980, OURE has codified a series of objectives representing staff policy and submitted them formally to the Assistant Secretary for Resource Applications for information.* These objectives are as follows:

- To be recognized as a dependable, long-term enrichment services supplier domestically and overseas by meeting present contracts and signing new ones

* OURE's annual practice in the PPBS.

- To meet or better competitors' prices and cover all costs of services
- To be the leader in enrichment technologies in order to track demands at lowest cost and know what options others have
- To operate the business with due regard to conserving uranium, U-235, and energy (power)
- To operate with due concern for proliferation and safeguards
- To preserve a wide range of options because of an uncertain future with options to:
 - maintain visibility of existing capacity
 - respond to changes in availability of power for diffusion plants
 - respond to market turns for separative work (SWU demands and plant availability)
 - take advantage of technological breakthroughs.

INNER DEPARTMENTAL COMMUNICATIONS

Traditionally, OURE reporting requirements were developed in years when top management changed less frequently and had a closer relationship with the enterprise. Because today DOE's top management changes more often and is responsible for other numerous and diverse programs, less time and attention are available to monitor OURE.

Members of the Resource Applications staff indicated to the review group that their information needs are not being adequately met. We examined monthly reports and certain other information regularly submitted and believe that all contain adequate information (see Appendix A, Question 9). If additional information or changes in format and content are needed, they should be developed jointly by OURE and those requiring the reports.

LEVEL OF FISCAL AND MANAGERIAL AUTONOMY

The enrichment enterprise is disrupted by changing government resource allocation priorities. The review group believes that establishing the revolving fund would be one way that OURE would be less affected by short-term budget trade-offs. Another way to provide more managerial autonomy to the enterprise would be to establish the enterprise as an independent agency.

Under a revolving fund (described in detail in Appendix A, Question 7), the enterprise would be released from the annual congressional appropriations cycle. The enterprise would then have more flexibility in implementing its budget within limits defined by statute. A longer-term decision horizon would also permit more flexible and realistic program planning and implementation. For example, excess revenues and investment return generated in one year could be used to modify the effects of sales slippages or cost increases in another year. Furthermore, the use of actual revenues rather than congressional appropriations would increase the enterprise's incentive to streamline operations, intensify marketing activities, refine pricing policies, and control costs.

The Bonneville Power Authority (BPA) uses a revolving fund, which provides it flexibility to finance long-term budget commitments. Revenues for BPA include receipts and collections from the sale of electric power and recoveries from the sale of bonds to finance its annual budget. BPA also has authority to borrow from the U.S. Treasury at rates comparable to open market rates for similar issues. Its long-term contracts provide for periodic electric rate adjustments to insure that BPA recovers all costs of operation and all capital invested in power with interest in keeping with statutory requirements.

Without further study the review group cannot comment on the issue of increased general management autonomy for the enterprise. The review group therefore suggests that DOE initiate a study of the advantages and disadvantages of establishing the enterprise as an independent agency similar to TVA or BPA.

Appendix A

BACKGROUND INFORMATION FOR MEETINGS, AUGUST 25-28, 1980

- OURE Responses to Questions Raised by the Review Group
- Issue Analysis Diagram
- Comments of Dr. Ruth M. Davis on Focus of Study

QUESTION 1:

WHAT ARE THE INTERNAL AUDIT PROCEDURES AND TECHNIQUES USED TO ESTIMATE AND CONTROL EXPENDITURES?

The budget and reporting for all Uranium Enrichment Program activities is performed in accordance with three principal DOE manual chapters. The three manuals are the 1101 Manual which covers all stat accounting; the 1301 Manual which deals with the budget requirements; and 6101 which specifically covers all aspects of construction.

The responsibility for internal audits to assure compliance with each of the above manuals is performed within DOE by the internal audit staff at Oak Ridge and by the Inspector General at headquarters.

In addition to the internal audits, the General Accounting Office also has overall oversight responsibility for all the federal procurement. As an example of a recent audit performed specifically for the Uranium Enrichment Program, the Annual Report includes audited financial statements for the period ending September 30, 1979. (A copy of this Annual Report was provided to the review group.)

Auditing by OURE for the Uranium Enrichment Program includes program costs which are planned and monitored on a monthly basis and are used as one of several means to determine potential problems which will require management attention. Projected costs are presented in the program plan prior to the start of the fiscal year which is about to be executed. The projected costs serve as a baseline to monitor program progress and also are reported to the Assistant Secretary for Resource Applications on a monthly basis. As variances occur, the cause and nature of the variance is identified and remedial action to the extent required is proposed. When a problem is identified that cannot be handled within the Office of Uranium Resources and Enrichment, options are investigated which can be presented to the necessary departmental officials.

Gaseous Diffusion

The techniques which are used to project program operating costs are based on the type of cost which is being

projected. In the operating area there are three categories of costs which can be reasonably separated and projected. The three major areas are cascade power, development costs, and plant operations costs.

For cascade power, the monthly projections of costs are based on the negotiated power levels and unit costs. For developmental costs the projections are based on the expected facility operations. As facilities are either started up or shut down, the levels by month will vary significantly. For plant operations costs, projections are based on the number of plant days within a given month. The only major change would occur as negotiated contract labor rates change.

In the construction area, costs are projected based on the schedule for each individual project. For new projects the costing rate will be typically lower at the start of the project than when it is nearing completion. In addition to the historical patterns which are used to forecast most projects, there are major schedule/cost systems which are used extensively.

Centrifuge Construction

The OURE programmatic goals and objectives for the GCEP project are provided to ORO for consideration and subsequent submission to the contractors prior to the preparation of the budget for a particular fiscal year. ORO then submits the resultant budget input to OURE for review and modification as necessary prior to its preparation and input into the PPBS, and the preparation and submission of the OURE/RA budget to the DOE Office of the Controller. Insofar as GCEP is concerned, this is the manner in which the GCEP project data sheets are prepared by ORO and OURE for subsequent submission to the Controller's Office. OURE provides the necessary data and defends, as required, the budget before DOE management review and OMB reviews. Subsequent to the submission of the budget to Congress, OURE provides data, assistance, testimony, and other input as required by the cognizant Congressional Authorization and Appropriations Committee. The foregoing is a description of the steps involved in the preparation and justification of the annual budget for the GCEP project.

Consistent with the OURE/ORO Management Charter for the Uranium Enrichment Program, the GCEP internal audit procedures and techniques which are used to audit and control expenditures include:

- a. Directed work scopes and allocations by ORO of total GCEP budget to each of several functions and the involved contractors, i.e.,
 1. Engineering (A-Es)
 2. Technical Support (UCC, SSC, AIR, etc.)
 3. Procurement (UCC)
 4. Construction (S&WEC).
- b. Utilization of all previously established GCEP project control activities as applicable, by each of the GCEP contractors in the planning, performance, management, and evaluation of their work.
- c. Monthly GCEP management meetings are held at which the GCEP contractors report on the status of their work-by-work breakdown structure, utilizing the GCEP Cost/Schedule Control System. The information presented and discussed and the issues resolved at a typical monthly management meeting are illustrated by GCEP documents (provided to the review group).
- d. GCEP project performance, costs, milestones, and other aspects of the project are monitored and reported to DOE management via the GCEP Monthly Status Report.
- e. Quarterly reviews are held with each of the three centrifuge manufacturers for purposes of reviewing progress, costs, milestones, and other problems. The scope and format of these meetings are evident from GCEP documents (provided to the review group).
- f. At annual intervals the GCEP project status is reviewed with the corporate management of all participating firms. The most recent such review was held at the GCEP project site on 8/4/80. The format and scope of this review is evident from a GCEP report (provided to the review group).
- g. At weekly and monthly intervals OURE reports GCEP highlights to RA management, and on a biweekly basis important GCEP events, problems, and accomplishments are reported to the Under Secretary.

- h. On an annual basis OURE prepares an Energy System Acquisition Project Plan (ESAPP) (provided to the review group).
- i. At 1-year intervals OURE, ORO, and the Controller's Office review the GCEP total estimated cost. The most recent such review was held on 8/13/80. The report on this review is now in preparation by the Controller's Office.
- j. At approximately 1-year intervals the GCEP project status is reviewed with the Chief Financial Officer. The most recent such review was held on 12/7/79. The unclassified portion of that presentation is available in GCEP records (provided to the review group).
- k. GCEP procurement actions up to \$15 million prime and \$25 million subcontracts are reviewed and processed by the Oak Ridge Operations Office. Procurement actions exceeding \$15 million are sent to OURE and other cognizant DOE headquarters components for review and approval.

Centrifuge Development

The gas centrifuge development budget funding is divided into eight categories termed budget and reporting classifications (B&RC). These B&RCs summarize all of the tasks funded by the development program into major program activities such as materials development, facility operation, centrifuge physics, etc. A financial plan, approved by this office before each fiscal year begins, allocates the forthcoming development budget funds among these B&RCs to the field offices according to the programmatic needs. A projection is then made on a month-to-month basis as to how these funds will be spent. Throughout each fiscal year, this office receives actual monthly expenditure reports for each B&RC. These are analyzed for compatibility with the financial plan. The field office must obtain approval from the headquarters branch responsible for centrifuge development before changing the planned expenditures for any B&RC item by 20 percent or more.

Additionally, this division participates in monthly program reviews held at the field office during which detailed expenditures are presented and justified. Major

budget reviews are held by this office at ORO during which a thorough analysis of the current and upcoming development budget is presented.

QUESTION 2:

THE REVIEW MEMBERS NEED ADDITIONAL EXPLANATION AND INFORMATION ABOUT OURE'S TREATMENT OF MARGINAL COSTS IN RELATION TO THE SCHEDULED RATE OF PRODUCTION. ANSWER WHETHER OURE IS TAKING ADVANTAGE OF IT NOW AND IN THE FUTURE.

In scheduling the rate of production, OURE considers marginal costs, but marginal cost is not the sole criterion used in the selection of production levels. The legislative requirement restricting DOE's charges to recovery of costs prohibits the making of a profit and, therefore, minimizing the selling price becomes the primary economic criterion. With a profit motive, production levels can be set so that marginal costs equal marginal revenues. This approach is not appropriate to OURE because of the lack of profit and perhaps more importantly because the demand is inelastic to price, at least in the short run. As a result, production levels are set to meet demand. With the decreasing demand projections of the last few years, production levels are being reduced. A decision has been made to reduce the production levels in the early years because of the impact on the price and budgetary considerations.

The lower production levels in the early years increase the unit cost of production significantly in those years. However, this higher unit cost of production does not result in a higher SWU charge because the carrying costs associated with a higher production level are eliminated. These carrying costs would occur because the higher production levels would not be needed until several years later. In addition to the impact on the charge criteria, the production reductions are taken in the early years to help meet department-wide budget targets.

Marginal cost analysis is an integral part of the EDIC model which confirms the selection of production drops in

the early years. Marginal cost analysis is the technique used in the economic studies of replacing existing gaseous diffusion capacity with centrifuge capacity. OURE uses and will continue to use marginal cost analysis as a parameter to be considered in scheduling future rates of production.

QUESTION 3:

WHICH COST COMPONENTS ARE SENSITIVE TO DEMAND? HOW DOES OURE HANDLE (E.G., MANAGE, CONTROL, MEASURE) THE SENSITIVE COMPONENTS?

GCEP

A major element for uranium enrichment production adjustment to meet demand is the schedule for introduction of Gas Centrifuge Enrichment Plant (GCEP) capacity. The near-term cost components of this adjustment are elements of the project capital cost. Since the initial project authorization, the schedule has been subjected to three major delays either to accommodate a reduction in demand or as a budget funding measure that was permitted by a low demand. During the early years of the project, the front-end schedule adjustments were relatively easy because schedules were very tight and the project was in the formative stage. The project is now very sensitive to future delays because the schedule has been stretched substantially and investment by private industry has been required in support of major component procurements. There are several critical suppliers in positions of marginal return on investment that could lose interest in the project if further delayed. The loss of one or more of these critical suppliers would have a devastating effect on the project.

Diffusion

Diffusion production levels established to meet demand are directly proportional to electric power. Since the sensitivity of power to demand is acute, OURE monitors this cost component very carefully. OURE maintains continuous contact via Oak Ridge personnel with DOE's three

power suppliers in order to develop both near-term and long-term power costs. Since power costs represent nearly 50 percent of the total production costs at an annual level of \$500-\$1,000 million, OURE monitors fuel (coal, etc.) cost projections for the electric power utilities. This allows OURE to estimate more closely the power costs 2 years in advance as required by DOE's budget process.

During the current budget year, costs are monitored on a monthly basis in a status report to OURE. Production, power, and their costs are monitored and variances are measured in order to develop alternative corrective actions. The monthly report is supplemented by daily verbal communication between OURE and ORO to provide early warning signals of potential power cost perturbations.

QUESTION 4:

THE REVIEW GROUP HAS A "GUT" FEELING THAT A SUITABLE SYSTEM EXISTS TO ENSURE COST REDUCTION AND COST EFFICIENCIES. BUT THEY WOULD LIKE OURE TO SHOW SPECIFIC PROCEDURES WHICH ILLUSTRATE THIS.

GCEP

The GCEP project design has a formal program of availability analysis which relates each element of the plant design to the cost of unavailability. The importance of GCEP availability is evident from GCEP records (provided to the review group). The GCEP design availability target is 98.5 percent.

The GCEP project has a formal systems engineering program whose elements are depicted in charts provided to the review group. In conjunction with the GCEP Systems Engineering Program, a series of Value Engineering (VE) studies have been completed -- others are still under way. The cumulative potential GCEP/VE savings and those already realized from VE studies completed and results applied were provided to the review group separately.

To achieve maximum economics and competition in GCEP construction, firm fixed-price construction contracts are being utilized fully.

Diffusion

OURE evaluates and implements gaseous diffusion operational cost efficiencies whenever possible. The following procedures illustrate this philosophy. The largest cost in a diffusion plant is electric power. It is supplied under long-term contracts and there is little if any control over the unit cost from the three suppliers. However, when DOE reduces power under letter agreements with the suppliers, the amounts reduced from each supplier represent, to the extent possible, the lowest cost production from the three-plant complex, as measured by the marginal productivity of the power at each plant.

Under circumstances where power generated in the dedicated OVEC and EEI stations is not adequate to meet DOE contract demand, OVEC and EEI are required to supplement the shortfall with power from their sponsoring utilities at a cost to them which is usually higher than the contract power. DOE has the right to accept or reject this supplemental power. OURE sets the criteria for determining whether or not the power should be purchased based on the marginal cost of the separative work that would be produced with the supplemental power; high if production is needed, low if not needed. If production is not essential (e.g., a high stockpile exists), considerable power cost savings are realized.

A significant portion of the equipment replacements are based on cost savings, and several years ago OURE authorized the contractors to reevaluate power recovery techniques in the gaseous diffusion plants. A project to demonstrate power recovery was authorized in the FY 1980 budget. This effort will evaluate the use of organic Rankine cycle turbines to recover waste heat generated by the gaseous diffusion plants. Approximately 4 to 6 percent of the total waste heat generated of about 300 million Btu/min is potentially recoverable. This will represent a power savings of 211 to 451 MWe at an annual cost savings of \$40 to \$80 million. If proven feasible, OURE will confirm the incremental cost/benefit.

potential of power recovery and proceed to implement this into the production complex.

Another example is the development, implementation, and management control of the CIP/CUP capacity expansion programs. These programs involved installation of new capacity at the lowest possible cost. Cost efficiencies are being realized with incremental production costs of \$17 and \$54 per SWU for CIP and CUP, respectively. Compared to the present production costs of around \$100 per SWU, this represents a substantial cost reduction. These programs are about 90 percent complete. About 9 million SWUs of this low cost capacity are now installed.

QUESTION 5:

EXPLORE FURTHER DOE'S AND OURE'S CAPABILITIES TO NEGOTIATE IN AND OUT OF ENRICHMENT CONTRACTS.

The TVA, OVEC, and EEI contracts specify the amount of power the suppliers must deliver and DOE must purchase annually through the early 1990s. Adjustments have been made when it was mutually advantageous for both parties, i.e., TVA could profitably, or at least without financial penalty, use the power DOE did not need in its own system or sell it to a neighboring utility without incurring added cost, or, conversely, if TVA needed power and was willing to compensate DOE, any added costs incurred by DOE for releasing the power to TVA (there would be no change in the cost of separative work to the toll enrichment customer).

EEI and OVEC are generally willing to reduce power deliveries to DOE if their sponsoring utilities can use the power from the dedicated plants without incurring increased costs to the sponsoring utility customers. These utilities are regulated by their state regulatory bodies and the Federal Energy Regulatory Commission. They cannot cancel scheduled deliveries to DOE if it will cost their customer more for the power. Failing a mutually satisfactory arrangement within the above restrictions, the only alternative is for DOE to cancel

power deliveries in the desired amounts and pay the suppliers the demand costs for the power not taken.

The contracts with all three suppliers contain cancellation clauses that permit DOE to cancel power with proper notice: 8 years for TVA, 10 years for EEI, and 5 years for OVEC. Cancelled power under these contracts cannot be restored under the existing contracts.

QUESTION 6:

REVIEW THE MANAGEMENT CONTROL AND RESPONSIBILITY STRUCTURE FOR THE GCEP PROJECT. SHOW CLEARLY WHO IS RESPONSIBLE FOR WHAT.

- A. ONE SPECIFIC QUESTION INVOLVED THE BUILDING TRADES PROBLEM: DOES DOE HAVE AGREEMENTS WITH ALL THE NECESSARY TRADE UNIONS?
- B. IDENTIFY ANY MAJOR PROBLEM AREAS.

The GCEP program/project management structure is depicted in relevant documents provided to the review group. The responsibility structure for the GCEP project is delineated in the OURE/ORO management charter for the Uranium Enrichment Program dated 4/1/79, and the portion applicable to GCEP was also provided to the group under separate cover.

- A. Does DOE have agreements with all necessary trade unions for the GCEP project?

It was never intended that DOE directly enter into collective bargaining agreements with the building trades for work on the GCEP project. Establishment of a formalized working relationship with the Building and Construction Trades Department (BCTD) and each of the affiliated national and international unions is the responsibility of the Stone & Webster Engineering Corporation (SWEC) in its contractual role as Construction Manager/Constructor (CM/C) for the GCEP project. Since an acceptable vehicle in the construction industry for attaining such formalized

working relationships with the building trades is a project agreement, the contract between DOE and SWEC provides in Appendix G, Section 3.1.15, that "...the CM/C is to plan for negotiation of a Project Labor Agreement...." SWEC formally initiated such negotiations with the BCTD in April of 1979.

In the interim, labor-relations experience at the GCEP site has been favorable. Work stoppages relating to contract expirations, strikes, jurisdictional disputes, etc., have been minimal and well handled by SWEC. Local union agreements have been adopted with no significant problems. The layered structure of fixed-price subcontractors, fixed-price prime contractors, SWEC, and DOE, has provided ample opportunity for resolution of disputes. The project is progressing without a project agreement, and the benefits to be derived by the project agreement have lessened considerably during the last 18 months.

B. The GCEP project is proceeding well; design and construction are on schedule; and the most recent review of the TEC (8/13-14/80) reaffirms the stability of the TEC, when allowance is made for inflationary changes.

The only major problem is the DOE year-to-year GCEP project funding and overall schedule variations and the impact of these variations on the industrial contractors who will be required to invest approximately \$250 million in manufacturing facilities in order to supply GCEP components. With the GCEP overall schedule uncertain, the ROIs on these facility investments are correspondingly uncertain. Consequently, the requisite level of private-sector capital investment may not be forthcoming to complete the GCEP project on its present basis.

QUESTION 7:

PROVIDE "WORDS OF EXPLANATION" ON THE REVOLVING FUND, A SCOPING PAPER. THE IDEA APPEARS GOOD AND ACCEPTABLE. HOWEVER, THE REVIEW MEMBERS NEED AN "OBJECTIVE" SUMMARY WITH RECOMMENDATIONS.

The Uranium Enrichment Program, unlike most government programs, provides a service which receives revenues for

value added to goods used. In terms of revenues, the Uranium Enrichment Program is equivalent to the top 275th U.S. corporation. The program's suppliers and customers are both private-sector entities. The program has a major capital project under way which will increase production capacity by about 25 percent. The rapidly changing domestic and foreign prospects for nuclear reactors and the business-type nature of the suppliers of inputs and users of outputs call for a financial system which provides far more management flexibility than is offered in the usual 3-year lead-time appropriations cycle. This increased flexibility can be provided through establishment of a uranium enrichment revolving fund and should result in greater overall economy and efficiency.

The uranium enrichment revolving fund would consist of all revenues from uranium enrichment-related activities, proceeds from the sale of bonds which would be authorized by the legislation, proceeds from the investment of fund assets, and the unexpended balance, as of the date of enactment of the legislation, of appropriations made for purposes related to the enrichment of uranium.

The legislation would authorize the Secretary, without further appropriation and without fiscal year and budget line item limitation, to make expenditures from the fund for purposes necessary or appropriate to the conduct of the Department's uranium enrichment activities as well as for payment of the principal, interest, and other costs related to bonds issued under authority of the legislation.

In recognition of the continuing congressional interest in the program, expenditures would be subject to limitations and directives that might be inserted into authorization and appropriation acts. Moreover, the Secretary could not acquire plant and capital equipment, the cost of which exceeds 5 percent of the total net book value of uranium enrichment fixed assets, or construct new enrichment capacity without express congressional authorization.

In addition, obligations for plant and capital activity purposes, which would increase expenditures for the capital activity budget to a level greater than 15 percent above that approved by Congress, could not be made until Congress has been notified and a period of 30 days while Congress is in session has elapsed.

The expected impact of the program in six major areas follows:

Budget Preparation

No change from the current system. In the initial few years, budget outlays will be less than the total financial resources available to the fund. The legislation will permit DOE to earn interest on the excess resources which would be available to finance future years' uranium enrichment activities.

Budget Implementation

The proposal will permit flexibility in implementing the budget up to a defined limit without going to Congress (i.e., the use of revenues and unexpended appropriation balances).

Program Management

The program manager must exercise intense management of program finances since the actual costs and revenues will control program implementation. Contractual terms and pricing policies take on additional significance.

Projects can be revised from budget projections. For example, the power recovery project is justified on a given level of power costs. If power costs should escalate faster than anticipated at the time the budget was prepared, the project could be accelerated if economically justified by rising power costs. There are a large number of projects in a similar situation.

Decision Horizon

Long-term economics can take greater significance. For example, the FY 81 budget includes

\$43 million for payment of demand (or termination) charges to TVA for power DOE chose not to purchase. Under a revolving fund, we would have sufficient resources and flexibility in implementing the budget to avoid actual payment of demand charges. The amount of unwanted power purchased in FY 81 would be dropped in a later year when we could avoid the demand charges. Total cumulative production would not change, and we would save \$43 million.

Sales Slippages Sufficient financial resources would be available to cover sales slippage for the next several years.

Cost Increases Again, sufficient financial resources are available to cover this possibility for the next several years. Increases in the unit cost of power is the main possibility for total cost increases.

QUESTION 8:

DOES OURE HAVE A CRITICAL ITEMS LIST? SHOW IT. WHAT ARE THE TROUBLES, PROBLEMS, ETC., AND HOW ARE THEY REPORTED? WHAT DOES OURE DO ABOUT THEM?

GCEP

The Gas Centrifuge Division does not have a critical items list by that title. For the development program, we receive from Oak Ridge a weekly critical items report that highlights major activities, accomplishments and problems. On the Gas Centrifuge Enrichment Plant project, the monthly status report includes a project manager's overview and assessment which highlights the status of

the project and any major problems or critical items. The Gas Centrifuge Division, in its Weekly Activities Report, identifies along with significant events any problems and critical items. The Division, in its monthly presentation to the Director (URE), identifies major problems and critical items. The problems include such items as technical problems, procurement delays, construction problems, approval and decision delays, labor problems, etc. The action by OURE depends on the particular problem. If this is a problem under the authority of the field office, URE's action is to review corrective action, work around, or schedule adjustments to determine the adequacy of the field responses. For problems under the authority of OURE or another headquarters organization, the OURE action is to expedite resolution and necessary approval.

Diffusion

OURE monitors key variables of its gaseous diffusion operations and production activities that are critical to the success of the enrichment problem. Key variables reported in the attached Monthly Status Report by ORO to OURE include the schedule and cost status of production, electric power, major construction projects (e.g., CIP/CUP) and the sales/revenues status. Variances in any of these areas are noted and explained and corrective actions are subsequently enacted by OURE and ORO. In addition, any potential problem areas are identified to OURE as an early warning system. Increased attention is given to these areas to rapidly respond to these events.

QUESTION 9:

PROVIDE EXAMPLES OF MONTHLY REPORTS AND ALL PERIODIC REPORTS. ATTACH A ONE-PAGE OR ONE-PARAGRAPH SUMMARY OF WHAT THE REPORT DOES.

GCEP

Examples of GCEP monthly and other periodic reports were previously referenced in response to question 1

and attached as exhibits.* One-paragraph summaries are provided below.

The GCEP Project Status Review is held monthly and is attended by all the major GCEP participants. Each participant gives a detailed report of the status of his work. Detailed cost information is also reported. There is much discussion and interaction between the participants, and problems are often discussed. Unresolved problems are assigned as action items to the responsible parties with a target completion date.

An example can be found in Exhibit 2.*

The GCEP Monthly Status Report provides management with a broad overview of the current status of the GCEP project. The project information that is reported includes status of design, centrifuge machine procurement, construction and technical support. In addition, manpower information and financial status is reported, including the cost and schedule performance (Performance Measurement System).

An example can be found in Exhibit 3.*

Reviews are held every three months for the three GCEP centrifuge machine manufacturers. Although the machine manufacturers attend the monthly project status reviews and report on their status, the quarterly reviews give a more detailed status review. These reviews allow a direct interface between the machine manufacturers, DOE, and other project participants who work with the machine manufacturers.

An example of these quarterly reviews can be found in the GCEP data in Exhibits 4, 5, 6.*

Corporate-level reviews of the GCEP project status are held periodically. Participants are briefed on the current status of the GCEP. The last corporate-level review was held at the GCEP site which included a tour of GCEP construction work. Participants typically include DOE management, high-level executives from the

* Exhibits were provided to the review group in a separate package.

corporations that participate in the GCEP project, members of Congress and/or their staff, and local news media.

An example can be found in Exhibit 7.*

Gaseous Diffusion

Conceptual Design Report: Outlines plans and defines requirements for proposed construction projects. It further provides justification, estimate of cost, and assesses benefits to be gained.

Assessment and Monthly Status Report to the Director, OURE: Provides to the Director a summary briefing on all activities concerning operations, construction, and maintenance of the GDPs.

Quarterly In-depth Review: Provides an item description of all subelement efforts necessary to complete a construction project. These subelement efforts are defined in terms of percent completion and funding expenditures.

Monthly Status Report (Yellowbird): Provides the Secretary for Resource Applications (RA) a summary of the Office of Uranium Resources and Enrichment (OURE) monthly efforts in the operations, construction, and maintenance of GDPs.

ORO Monthly Capacity Expansion Program Report: Provides a progress report summarizing work accomplished and funding status for the Cascade Improvement Program (CIP) and Cascade Upgrading Program (CUP).

GDP Reliability Study Program: Provides a complete assessment of GDP equipment status. This assessment identifies outmoded or obsolete equipment requiring replacement and also indicates where present state-of-the-art equipment has been installed and functioning. All GDP equipment capabilities are evaluated. One volume summarizes the findings. Supplemental volumes address individual equipment capabilities and drawbacks with alternatives for correction.

* Exhibits were provided to the review group in a separate package.

Quarterly Progress and Status Report (Construction): Summarizes all construction project progress to date (line items).

Quarterly Progress and Status Report (General Plant Projects): Summarizes all GDP progress to date.

Project Management Plan: Provides a project description, technical objectives, and project schedules and costs for individual construction efforts.

ORO Monthly Production Activities Report: Summarizes GDP enriched uranium operations.

ORO Management Report for GDPs and Long-range Technical Support: Provides status of the major milestones in four mission areas: 1) CIP/CUP, 2) technical support to assure plant capacity, 3) safety, and 4) conservation.

Monthly Narrative Highlights: Provides narrative report on construction project progress.

Program Management Summary Reports: Provides construction, funding, and critical milestones information for each line item construction project.

Closing Statement of Cost: Provides final cost figures for a completed project and compares this cost to the amount authorized.

Report of Significant Activities: Provides to the Acting Deputy Assistant Secretary a summary of significant events/problems encountered during the previous week.

GDP Management Plan: Provides guidance and direction to ORO pertaining to management controls on general plant projects. This management plan stipulates the procedure required to gain approval for candidate GDP efforts.

The following reports are monthly progress reports prepared by contractors that highlight gas centrifuge development progress. Summaries of significant activities are presented as well as operational details of existing facilities. The reports range in size from 25 to 100 pages of technical detail regarding the development tasks funded under the budget and reporting classifications. The reports are secret, restricted data.

- 1) Union Carbide Corp. - Nuclear Division (UCC-ND) - Gas Centrifuge Program Report and Appendix (two reports)
- 2) AiResearch - Centrifuge Program Monthly Status Summary
- 3) University of Virginia Gas Centrifuge Monthly Status Summaries
- 4) Monthly Summary Report of the Los Alamos Scientific Lab (LASL) Gas Centrifuge Research Program.

This Division also receives from the Garrett Corporation a Monthly Status Summary for the Commercial Gas Centrifuge Research and Development Program. This report highlights certain specific R&D tasks that are funded with this corporation.

This Division receives two weekly activities reports from Oak Ridge Operations: one from the Centrifuge Machine Office and one from the Director, Centrifuge Technology Division. These reports provide summaries of centrifuge development activities and critical items that require management attention. These provide a status of activities for both centrifuge development activities and machine manufacturing.

QUESTION 10:

SHOW A PROBABILITY COST CURVE OF SHUTTING DOWN PRODUCTION, I.E., WHAT IS THE PROBABILITY OF DEGRADATION AND THE COST VS. BENEFITS ASSOCIATED WITH IT? OR WHAT IS THE GAIN VS. RISK OF SHUTTING PRODUCTION DOWN?

We do not have enough operational experience to develop a low-power probability cost curve. However, some of the problems encountered during low-power operations and cells placed in standby can be addressed. Under CIP/CUP many of the improvements were specifically designed for high-power operations, and consequently at a late stage of CIP/CUP it is more difficult to operate the plant at low-power levels. Some of the problems encountered are: a greater risk of UF₆ freezeout (especially in cold weather), an

increased risk in fouling condensers, cooling tower degradation, and pumping problems in the high-capacity pumps at low-flow rates. Low-power operation requires some separation cells to be placed in standby, generally by evacuating the UF₆ process gas and replacing it with nitrogen or dry air. Careful monitoring of these cells is required, and there is concern for the integrity of the CIP improved barrier under prolonged standby conditions. It is also a little more difficult to control the equipment on-stream under low power conditions and surging; particularly at Paducah this is more difficult.

When restarting, standby cells, seals, and compressors are often damaged, requiring increased maintenance.

By reducing power to the cascade, substantial dollars are saved. The offsetting higher maintenance costs and separative work mixing losses are small by comparison.

QUESTION 11:

THE REVIEW MEMBERS NEED A BETTER EXPLANATION OF THE INCREMENTS OF PRODUCTION IN BOTH CENTRIFUGE AND DIFFUSION (ONE TRAIN VERSUS ONE STAGE OR CELL) SO THAT THEY CAN UNDERSTAND THE INCREMENTAL COST FOR PRODUCTION, REPLACEMENT, AND ADDITIONAL CAPACITY.

The GCEP plant of 8.8 SWUs consists of eight process buildings, each containing eight trains. Each train consists of six cascades of machines and each cascade contains a large number of machines. The capacity of each cascade is 23,000 SWUs; the configuration of a process building, and the relationship of the trains and cascades is shown in material provided to the review group.

In a diffusion plant there are basically three sizes of equipment: 0.00 and 000 size converters. There are 10 converters per cell for 0 and 00, and eight for 000. Separative work capacity and productivity of each cell is classified. If it is desirable to increase productivity or capacity of a diffusion cascade, cells may be bypassed or power, and thus pressure, of the gas reduced, or a combination of both bypass and power reduction used.

QUESTION 12:

IT APPEARS THAT IT IS NOT A GOOD DECISION TO CUT BACK ON THE GCEP SCHEDULE FOR AIS. BUT WHAT ARE THE MILESTONES OR DECISION POINTS FOR THIS EVALUATION?

There are currently no plans to cut back on the GCEP schedule for AIS. The Under Secretary has requested that the Energy Research Advisory Board (ERAB) review (among other issues) the risks, benefits and costs associated with AIS technologies and whether they are realistically competitors to GCEP. The ERAB work, we understand, will be completed in early fall. Even if ERAB, however, concludes that AIS technologies are not yet at that point, we suspect that this issue will be revisited annually for the next several years prior to committing to construction of each individual GCEP building.

If consideration is to be given to delaying process buildings 3 through 8 beyond the dates associated with the GCEP amended by FY 1981 budget (i.e., completion of 8.8 MSWU by 1994), then this decision must be made not later than the fall of 1982. The significance of this milestone is that this is when the decision must be made concerning the level to which the centrifuge machine suppliers scale up their machine-manufacturing capabilities and make commitments for additional centrifuge manufacturing facilities.

The draft AIS major system acquisition plan indicates a key decision point at the end of FY 1986. At that time, AIS engineering development will be complete and a decision is needed to proceed with the AIS demonstration phase. This is also the date for transfer of AIS responsibility to OURE. The key date in the AIS plan for a decision on developing AIS production capability is at the end of FY 1988.

QUESTION 13:

HOW DOES OURE USE COMPUTER MODELS IN ITS DECISION MAKING?

OURE uses several computer programs as input to its decision making. An enriched uranium demand model and an

enrichment complex production simulator model are used in preparing operating plans that are used in the development of alternative budget strategies.

A financial model is used to develop prices, discounted cash flows, and net cash requirements for alternative operating plans. Since the Uranium Enrichment Program is on a cost-recovery basis, minimizing the charge in the short and long run has been established as a criterion for the evaluation of operating strategies. Also, the ability of the program to pay its own way and operate in a positive cash flow as long as possible is another criterion. The model provides the necessary output to compare the alternatives against the established criteria.

An optimizing economic model of the enriched uranium industry is also used to a limited extent to identify methods of meeting demand based on minimizing combined customer and DOE costs for varying sets of assumptions. The resulting outputs thus provide some cost trends which are helpful for identifying decisions which are reasonably economically optimum.

QUESTION 14:

THE REVIEW MEMBERS NEED SHORT SYNOPSSES OF THE COMPUTER MODELS BEING USED -- WHAT THEY ARE BEING USED FOR AND A SHORT DESCRIPTION OF THE LOGIC OR METHODOLOGY USED IN THEM.

Synopses of each of the principal models in use by OURE are as follows:

Reactor Status Reporting System - REST

REST is a computer program/data-base system for storing, retrieving, and summarizing data concerning the status of nuclear reactors. It was developed as an interim system, pending the development and completion of a more formal and sophisticated method which will use the System 2000 (S2K) data base management system. However, it has the potential of being a useful adjunct to reactor status

analysis through its capability of allowing quick, ad hoc modification to data during the course of enrichment planning studies.

Inputs include reactor name, type, fuel cycle length, historic commercial operating date (if reactor is operating), and planned future commercial operating dates for various growth cases. Outputs consist of detailed reactor-by reactor listings, gigawatt growth summaries for individual reactor types on an annual and cumulative basis, and summaries for all reactors in a given data file. In addition, an MWe growth file may be created to use as basic input into the "SWUP" separative work projection model.

Separative Work Projection Model - SWUP

SWUP is a program which translates GWe growth by reactor type, operating mode, and contract type into enriched uranium demand at the enrichment sites. Standardized reactor models time-phased to commercial operating dates have been developed based on data recently collected from utility, vendor, and government sources. These models use historical lead time data and reflect alternative reactor types (BWR or PWR), alternative refueling intervals (12-month and 18-month), and different enrichment contract constraints (fixed commitment contract and requirements contract). The output of this model can be an input to the enrichment complex simulator model.

Uranium Enrichment Activity (UEA) Simulator - GDPX

Given annual enrichment complex separative production civilian and government demands, feed availabilities, and other parameters, the model computes and reports feed and separative work balances (including feed purchases and new plant separative work if required) around the Uranium Enrichment Activity (UEA) complex. The model also reports the schedule of feed usage on a yearly basis and the feed and separative work contents of the demands and product inventories for both transaction and operating tails assays as well as any specified evaluation tails assay.

The model uses the standard equations for separation of the binary mixture, U-235 and U-238, in doing the computations. The model is primarily used to examine different

scenarios utilizing alternative mixes in the use of natural uranium and low-enriched uranium inventories, power to the gaseous diffusion complex, availability of gas centrifuge capacity, etc. The combination of input and output of the model serve to define all of the parameters of an operating plan.

Financial Model

OURE has developed a financial model to (1) arrive at the charge for enrichment services, (2) prepare schedules for cash flow, (3) measure the short- and long-term impact on the cost of production and selling price of proposed actions, (4) compare OURE price projections with our competition, and (5) arrive at prices and borrowing requirements for the proposed revolving fund.

The financial model takes the input financial and production data and generates the additional data needed to arrive at prices and schedules of cash flow. The model produces imputed interest costs, income statements, cost of goods sold, depreciation schedules, and advanced payment schedules that are needed to arrive at annual price projection. The extensive financial output is required because of the cost recovery pricing methodology. The financial data calculated for one year provide the beginning balances for the succeeding year's charge.

EDIC Model

The EDIC model is a model in place at Oak Ridge. Although once used extensively, it is now used relatively infrequently. It is designed to simulate the enrichment complex, with suitable economic criteria incorporated so that it will develop economically optimum modes of operation with various optional input constraints. Through a series of sensitivity analyses over a plausible range of input assumptions, trends can be identified which are useful in decision-making. The model is not designed to provide absolute results. The model was used recently to identify the sensitivity of AIS introduction dates or overall enrichment economics. The model derives the name EDIC from its optimizing criterion: equal discounted incremental costs. The EDIC criterion as given above is

a simplified statement of the basic criteria for economic optimization. Two basic criteria are involved:

1. Optimal Activity Level: The scale of an activity should, if possible, be expanded so long as its marginal net yield (taking into account both benefits and costs) is a positive value; and the activity should, therefore, be carried to a point where this marginal net yield is zero.
2. Relative Activity Level: For optimal results, activities should, wherever possible, be carried to levels where all yield the same marginal returns per unit of effort (cost).

These criteria, taken together with the fact that the cost of money is one of the relevant costs, lead to the more simply stated EDIC criterion. The objective, under the EDIC criterion, is to obtain minimum-cost enriched uranium taking into account the costs of both feed and separative work. Specifically, the objective is to minimize the present value of the combined controllable costs of DOE and its toll enrichment customers, referred to as the Total Enterprise Cost (TEC). The principal tradeoffs to which the EDFIC criterion applies are feed versus separative work, and production versus time. Thus the marginal cost relationships to which the optimizing criterion applies are specifically derived for the variables of uranium enrichment.

Inputs to the EDIC model include cost and performance data on existing and new plants, tails assay levels, cost escalators, and various special constraints. Output of the model includes a summary of operating plan parameters (power levels, tails assays, feeds, etc.), costs by category, total annual costs, and costs of the total campaign.

QUESTION 15:

ANSWER THE FOLLOWING IN REGARD TO THE COMPUTER MODELS OURE USES:

- WHAT ARE THE INPUTS?
- WHAT DEGREE OF CONFIDENCE DOES OURE HAVE THAT THEY ARE NOT PUTTING "GARBAGE" IN?

- WHAT ARE THE OUTPUTS?
- HOW ARE THE MODELS VALIDATED? BY WHOM? PROVIDE THE LATEST VALIDATION.
- WHAT HAS EXPERIENCE SHOWN? HAS IT PROVED THE MODEL TO BE ACCURATE? IS THERE AN EXAMPLE?
- WHAT IS OURE'S RESPONSE TO THE OPINION THAT THE COMPUTER MODELS BEING USED ARE "OLD AND CREAKY?"
- WAS THE MODEL LIMITED BY COMPUTER CAPACITY WHEN IT WAS DEVELOPED? IS IT LIMITED NOW?
- ARE THE MODELS AVAILABLE INDEPENDENT OF OTHER COMPUTER MODELS?

The above questions are answered below for each computer model currently being used by OURE for forecasting nuclear power growth and developing operating plans for the enrichment complex.

EDIC Model

What are the inputs? The principal inputs are demands for enriched uranium, unit power costs for gaseous diffusion power, other gaseous diffusion plant operating costs, unit feed costs, gaseous diffusion plant production as a function of power, costs of new enrichment capacity, and an interest rate for the cost of money over a campaign period.

What degree of confidence does OURE have that they are not putting "garbage" in? There is, of course, great uncertainty with respect to many of the input assumptions used, particularly due to the long period of time considered. It is, therefore, necessary to determine the sensitivity of the system costs, or other features of interest, to alternative operating decisions over a plausible range of input assumptions. The resulting response, together with probabilities assigned to the varying input assumptions, then provide the basis for identifying decisions which are economically attractive in terms of the program objectives.

What are the outputs? The outputs include a time-phased summary of operating plan parameters (gaseous diffusion plant power levels, inventory levels, tails assay, feed requirements, new enrichment plant requirements, etc.), costs by category, total annual costs and costs of the total campaign.

How are the models validated? By whom? The model was thoroughly reviewed in the late 1960s by several organizations. An AEC planning and analysis group (headed by Roger LeGassie) independently reviewed and verified the model. Another AEC group developed a general nonlinear optimization model which used a totally different mathematical procedure which provided almost a near duplication of the EDIC outputs. The EDIC model also was generally accepted by the technical community at that time as well as by the Congress and Bureau of the Budget (now Office of Management and Budget). More recently the Energy Information Administration (EIA) made a cursory review of the model structure and operation and determined both to be sound (see attached exhibit).

What has experience shown? Has it proved the model to be accurate? Is there an example? Not applicable.

What is OURE's response to the opinion that the computer models being used are "old and creaky?" The model was developed in the mid-1960s and, therefore, could be considered "old." It has been modified since then, of course. A major point is that the economic optimization procedure remains still valid and is not a function of age.

Was the model limited by computer capacity when it was developed? Is it limited now? No, in both instances. It did, however, require considerable machine time.

Are the models available independent of other computer models? Yes; however, some computer models are used to generate some of the input such as the gaseous diffusion plant production characteristics.

Financial Model

What are the inputs? The model requires both financial and production data as inputs. The major financial inputs are:

- Investment in plant and equipment, inventories, and working capital
- Accumulated profit and loss
- Accounting policies and practices for depreciation, costing of inventories, etc.
- Projected costs for future years
- Sales projections
- Inflation rate cost
- Cost of money
- Pricing periods

The production data include:

- Annual production levels
- Changes in inventory levels.

What degree of confidence does OURE have that they are not putting "garbage" in? We have a high degree of confidence in the validity and accuracy of the input data. Much of the financial data comes from audited financial statements. The projection of future costs is known with considerable accuracy based on previous experience. The production data and sales input data are discussed in the other models.

What are the outputs? The model produced a wide range of outputs including:

- Cost of enrichment services by year by contract type
- Schedule of cash flow
- Financial statements, including income statements, cost of goods sold, and depreciation schedules

- Borrowing requirements for the revolving fund proposal.

The model can produce these outputs for a sensitivity analysis of any single or combination of changes of inputs.

How are the models validated? By whom? Provide the latest validation. The model has not been validated. However, the model is based on the pricing methodology and financial system that has been consistently utilized since the beginning of toll enriching and that has been reviewed and approved by GAO. The GAO reviewed and approved the systems in the early 1970s and has periodically made spot checks.

What has experience shown? Has it proved the model to be accurate? Is there an example? The model was developed in the winter of 1979 and spring of 1980 and, therefore, experience has been limited. The results to date prove the model to be accurate based on past trends and non-model analysis.

What is OURE's response to the opinion that the computer models being used are "old and creaky?" The financial model is certainly not old, and, in DOE's opinion, it is not creaky.

Was the model limited by computer capacity when it was developed? Is it limited now? No, in both instances.

Are the models available independent of other computer models? The financial model is independent of the older models, except that it does some of the output of other models.

Reactor Status Reporting System - REST

What are the inputs? The principal inputs are individual reactor files which include the net megawatt generating capacity, reactor type, planning refueling interval, the historic commercial operating date (if the reactor is operating), planned future commercial operation dates for various growth cases, and a contract termination date -- if such is known.

What degree of confidence does OURE have that they are not putting "garbage" in? We have a high degree of confidence on much of the data. Of course, any forecast of future nuclear power growth is fraught with uncertainty. We do review these projections semiannually. Our current projections agree reasonably well with recent projections made by other government and industry groups.

What are the outputs? The outputs include detailed reactor-by-reactor listings, summaries for individual reactor types on an annual and cumulative basis, and summaries for all reactors in a given data file. In addition, an MWe growth file may be created to use as basic input the "SWUP" separative work projection model.

How are the models validated? By whom? Provide the latest validation. Validation is somewhat inappropriate. This model is simply a manipulator of data. It has been checked and shown to be mathematically precise.

What is OURE's response to the opinion that the computer models used are "old and creaky?" REST was developed in late 1979 and is certainly not old.

Was the model limited by computer capacity when it was developed? Is it limited now? No, in both instances.

Are the models available independent of other computer models? Yes.

What has experience shown? Has it proved the model to be accurate? Is there an example? Not applicable.

Separative Work Projection Model - SWUP

What are the inputs? The principal inputs are fuel cycle characteristics for various reactor types and refueling intervals, historical lead times, capacity factor, empirical constraints because of contract flexibility limitations, and projected gigawatt growth by reactor type and expected operating mode.

What degree of confidence does OURE have that they are not putting "garbage" in? We have a high degree of confidence in much of the data in that a detailed review of the basic reactor operational data was completed in June.

1980. It reflects history to date and generally the current thinking of utilities and vendors. The major uncertainty, of course, is the projection of nuclear power growth which must be used to develop the SWU projection.

What are the outputs? The outputs include year-by-year enriched uranium requirements and for a reference tails assay, SWU, and natural uranium requirements. The annual enriched uranium requirements can then be used in the enrichment complex simulator model.

SWUP Model

How are the models validated? By whom? Provide the latest validation. The model has not been validated. The model is very simple and its validity is totally dependent upon the assumptions therein. As noted earlier, the bulk of the assumptions reflect the experience to date and the current thinking of utilities and vendors. The error band in these assumptions is relatively small compared to the uncertainty in nuclear power projections. We also have a consultant developing independently a more sophisticated and comprehensive SWU projection system. This effort is scheduled to be completed next year. These two separate models should serve as a means of validation, one for the other.

What has experience shown? Has it proved the model to be accurate? Is there an example? The model was only developed in late 1979 and early 1980; therefore, the experience is very limited.

Is it OURE's opinion that the computer models being used are "old and creaky?" SWUP was developed in late 1979 and early 1980 and is certainly not old and creaky.

Was the model limited by computer capacity when it was developed? Is it limited now? No, in both instances.

Are the models available independent of other computer models? Yes; however, as noted earlier, SWUP can be utilized in conjunction with REST.

Uranium Enrichment
Activities Simulator - GDPX

What are the inputs? The model requires inputs that can be grouped into four data categories consisting of demand, production, inventories, and operating variables. The inputs required for each of these categories are listed below.

- Demand
 - Annual U.S. and non-U.S. civilian enriched uranium described by triplets (i.e., MTU, MTU-235, value function)
 - Annual net government and other non-power demand described by triplets
- Production
 - Annual gaseous diffusion plant production in million SWU
 - Annual gas centrifuge plant production in million SWU
- Inventories
 - Beginning inventories of enriched uranium, natural uranium, and depleted uranium by quantity and assay
 - Annual natural uranium deliveries other than normal toll enriched deliveries
 - Annual credits for customer inventories included in DOE inventories
- Operating Variables
 - Annual operating and transaction tail assays
 - Years, if any tails recycle is allowed
 - Order of feed usage by feed sources
 - Enrichment level for the pre-produced product enriched uranium stockpile.

What degree of confidence does OURE have that they are not putting "garbage" in? We have a high degree of confidence that the data being put into the model are the best available based on the assumptions available at the time other data are prepared. The inputs with the greatest degree of uncertainty are the projected demand data.

What are the outputs? The outputs consist of 37-page printouts, including tables showing input data, a separate work balance, a feed balance, and inventory management tables.

How are the models validated? By whom? Provide the latest validation. The model has not been validated; however, the model is very simple and its validity is dependent on the standard equations for separation of the binary mixture, U-235 and U-238, in doing the computations. These equations were developed during the 1940s and since that time have been extensively used by both government and industry.

What has experience shown? Has it proved the model to be accurate? Is there an example? The model was developed during 1973 and since then has been used by several clients other than OURE. Minor problems have been found in the model, basically in the way the beginning inventory of enriched uranium was handled by the model if the inventory was at an enrichment level other than that specified to be made by the model. This problem was rectified by adjusting the input beginning inventory to be consistent with the input assay for enriched uranium to be pre-produced by the model. Several other minor problems were found that were fixed. The model has been updated several times to fix both minor problems and to add additional input and output features.

What is OURE's response to the opinion that the computer models being used are "old and creaky?" Even though the GDPX was written in 1973, the model has been updated several times. The current models offer several features not included in the original version. Problem areas have been found and fixed. The model is not considered to be old or creaky.

Was the model limited by computer capacity when it was developed? Is it limited now? No, in both instances.

Are the models available independent of other computer models? Yes. The GDPX can be used using demand data generated by SWUP or demand data can be inputted from other sources. A memorandum dated August 5, 1980, reviews documentation on the EDIC model.

QUESTION 16:

PROVIDE A GENERIC DESCRIPTION OF OURE'S DEMAND FORECASTING.

The Office of Uranium Resources and Enrichment (OURE) semiannually reviews and updates its projections of nuclear power capacity to be supplied by DOE enrichment plants.

Projections through 1995 are derived on the basis of a detailed examination of each reactor now in the pipeline, i.e., planned, ordered, under construction, or operating. The factors used in determining the domestic estimates included the current construction and licensing status and the length of time that would be needed to complete the project based on NRC historical statistical data, and financial, environmental and load growth considerations. Data sources for the latter three factors include the enrichment contracts, utility announcements, EIA analysis, industry consultant data, and media information. Projections in the post-1995 period are made using EIA's latest official projections.

With respect to non-U.S. nuclear power, each non-U.S. reactor currently under a DOE contract is examined in detail in a manner analogous to developing the domestic forecast using country-specific data derived from international cables, marketing missions, market surveys, and industry consultants. For those non-U.S. contracts which expire during the planning period, a judgment is made on the likelihood of that customer remaining under contract with the United States or going to another supplier. For new growth, a country-by-country evaluation of official nuclear plans is made and an assessment made of the likelihood of achieving the plans as well as the potential for the United States to obtain an enrichment contract.

The separative work requirements (corresponding to the nuclear power growth projections discussed above) are developed using standardized boiling and pressurized water once through cycle reactor models. These models were reviewed in the spring of 1980 by the Joint OURE/ORO Planning Team which concluded that the standard annual reactor models accurately reflected customer fuel cycle data. However, the task force recommended that since a significant fraction of DOE customers (about 1/3) had already indicated plans to operate using longer refueling intervals, reactor models using both 12- and 18-month refueling intervals should be developed and included in the planning base. This recommendation was accepted and the new models were incorporated.

The fuel cycle lead times used for the planning models reflect actual customer historical experience. A long-term effective average capacity factor (considering fuel utilization efficiency experience) of about 66 percent of design was assumed for the 12-month refueling schedules and 70 percent of design for the 18-month refueling schedules.

The gigawatt growth projections and corresponding separative work demand discussed above are calculated using a series of computer data files and programs. Files containing individual reactor data are maintained using the REST program.

The REST program also calculates annual and cumulative gigawatt totals by contract/reactor/fuel cycle types and creates data files for use by the SWUP program. SWUP takes the annual gigawatt totals generated by REST and calculates SWU and natural uranium feed requirements using the appropriate model data. SWUP also creates a file containing the necessary data for use in GDPX. The GDPX program using demand and operating data calculates separate work and feed balances for the enrichment complex. These balances are used in developing enrichment operating plans.

QUESTION 17:

SHOW A SPECIFIC EXAMPLE OF OURE'S METHODS TO ASSESS THE MARKET, FOR EXAMPLE, COMMONWEALTH EDISON AND JAPAN (KANSAI IN PARTICULAR).

Here are examples of two markets.

Commonwealth Edison

Table 1 lists nuclear power plants (operating, under construction, or planned by Commonwealth Edison) that were evaluated by OURE in preparing the June 1980 nuclear power growth projections. Of the sixteen reactors listed, seven are operating, six under construction, two planned, and one uncertain. For the operating reactors, it was assumed that current reactor operating experience would prevail through the period. The procedure for projecting the commercial operation dates (COD) for the seven reactors under construction was similar for each reactor and is outlined in detail for the Braidwood units below:

1) The construction status (percent complete) was obtained from NRC's February 1980 Construct Status Report For Nuclear Power Plants (Yellow Book) which indicated 54-percent complete for Unit-1 and 43-percent complete for Unit-2. The report also noted that construction had been halted. An estimated fuel loading date was then calculated using curves prepared by NRC and assuming the construction had been resumed. Six months were added to the resultant dates to arrive at estimated CODs. The results were a 1983 COD for Unit-1 and a 1983/1984 for Unit-2. These dates were compared with the applicant's current estimated fuel load date that was also listed in the Yellow Book and six months added to come up with an estimated COD. The applicant's estimated COD was October 1982 for Unit-1 and October 1983 for Unit-2.

2) A literature survey was made with the most pertinent information being found in the 1979 Commonwealth Edison Annual Report that stated that if construction were resumed on the units in the spring of 1980, CODs of 1983 and 1984 could be met.

Table 1
OURE's June 1980 Nuclear Power Growth Projections
Commonwealth Edison

<u>Reactor</u>	<u>Contract Type</u>	<u>Expiration Date</u>	<u>Reactor Type</u>	<u>Net MWe</u>	<u>Commercial Operation Date</u>		
					<u>High</u>	<u>Mid</u>	<u>Low</u>
BRAIDWOOD-1	AFC	2011	PWR	1120	1984	1985	1986
BRAIDWOOD-2	AFC	2012	PWR	1120	1985	1986	1987
BYRON-1	RT	2001	PWR	1120	1983	1984	1985
BYRON-2	RT	2001	PWR	1120	1984	1985	1986
CARROLL COUNTY-1	FC	2014	PWR	1120	1992	1994	1996
CARROLL COUNTY-2	FC	2015	PWR	1120	1993	1995	1997
COMM ED-1	FC	2013	-	1150	-	-	-
DRESDEN-1	AFC	2009	BWR	200	1960	1960	1960
DRESDEN-2	RT	1998	BWR	794	1971	1971	1971
DRESDEN-3	RT	1998	BWR	794	1972	1972	1972
LA SALLE-1	RT	2001	BWR	1078	1981	1982	1982
LA SALLE-2	RT	2001	BWR	1078	1982	1983	1983
QUAD CITIES-1	RT	1998	BWR	789	1973	1973	1973
QUAD CITIES-2	RT	1998	BWR	789	1973	1973	1973
ZION-1	RT	1999	PWR	1040	1973	1973	1973

3) COD projections made by EIA during the spring of 1980 for their annual report to Congress were examined. The EIA projection indicated CODs later than those projected by either the utility or by using the NRC data. Specifically, Unit-1's high/mid/low case projections were 1984/1985/1986 and Unit-2's were 1985/1986/1987.

4) Discussions held with DOE Sales Support personnel at the Oak Ridge Operations Office indicated their expectation that the two units would not reach COD until 1985, and 1986. (The Sales Support personnel at Oak Ridge have frequent informal discussions with the utility personnel and therefore often reflect utility thinking that may not yet be publicly-announced policy.)

5) Projections by a private industry consultant were also examined. Their COD projections also indicated later dates than were currently estimated by the utility with most likely dates being 1984 for Unit-1 and 1986 for Unit-2.

6) The information obtained in parts 1 through 5 above was examined and a judgment made to use the dates indicated in Table 1. The selected CODs reflected the independent analysis of three groups (i.e., ORO Sales Support, EIA, and an industry consultant) that the mid-1980s were the most likely time-frame when commercial operations could be achieved. A one-year spacing between Units -1 and -2 also was included to be consistent with previous utility spacing plans.

The procedure for estimating CODs for the two Carroll County units and Comm Ed-1 that have not begun construction, was similar to that of those plants under construction with the exception of the NRC step. Since these units had not entered the NRC licensing process, the projection was based on the best estimates available from the utility and projections made by EIA and our industry consultant. Commonwealth Edison's 1979 Annual Report stated that the two Carroll County units would not reach commercial operation until the early 1980s. The March 1980 issue of the "U.S. Central Station Nuclear Electric Generating Units: Significant Milestones" report put out by DOE's Office of Nuclear Reactor Programs showed CODs of October 1992 and October 1993 for the two units. These two dates were supported by information obtained from our industry consultant. EIA, however, believed in their mid

and low scenarios that the projects would be delayed even further into the 1990s. We elected to take the 1992 and 1993 dates for the high case scenarios with 2-year delays between the mid and low cases in consideration of the negative EIA projections. Comm Ed-1 was not considered to be a real plant by any of our sources and therefore was not included in the projections.

Japan

Table 2 lists all Japanese nuclear power plants and their projected CODs contained in OURE's June 1980 nuclear power growth forecast. Table 3 highlights those reactors belonging to Kansai Electric. Of the thirteen Kansai reactors, seven are operating while the remaining six are either under construction, seeking construction permits, or planned. The method for determining CODs for the Kansai reactors is similar to that used for Commonwealth Edison. A detailed discussion of the selection process for Kansai-1 and -2 is given below:

1) Since neither Kansai-1 nor -2 is shown in the literature as being under construction, a literature search was made to determine when a construction permit might be issued for the two units. The December 1979 issue of "Nuclear Engineering International" contained a survey of Japan's nuclear program that stated that the two units (referred to as Takahama-3 and -4) had been authorized by EPRDCC and that construction was to start in June 1979. However, an "Energy Daily" article dated November 30, 1979, stated that the construction permit for Takahama-3 and -4 had not been issued but was expected in March 1980. Information received through our Marketing Branch from Mitsui New York dated November 8, 1979, indicated that the construction permit for two units had not yet been granted. Assuming that the March 1980 date might be valid, an estimated COD of early 1987 for Unit-1 was calculated based on information contained in an NRC report of April 16, 1979 titled "U.S. vs. Japanese Reactor Construction Times." Literature information indicated that Unit-2 was planned to follow Unit-1 by about 6 months. Using this same spacing, Unit-2 would then be expected to reach COD during the second half of 1987; however, since there was no confirmation that a construction permit had been issued in March 1980, a 1988 COD was assigned to Unit-2.

Table 2
OURE's June 1980 Nuclear Power Growth Projections
Japan

<u>Reactor</u>	<u>Contract Type</u>	<u>Expiration Date</u>	<u>Reactor Type</u>	<u>Net MWe</u>	<u>Commercial Operation Date</u>		
					<u>High</u>	<u>Mid</u>	<u>Low</u>
Chubu-3	AFC	2018	BWR	1092	1990	1990	1991
Chubu-4	AFC	2019	BWR	1045	1990	1992	1992
Chubu-5	AFC	2016	BWR	1092	1988	1992	1996
Chubu-6	AFC	2017	BWR	1092	1989	1993	1997
Chugoku-4	AFC	2019	BWR	1093	1992	1992	1993
Chugoku-3	AFC	2017	BWR	1045	1991	1992	1996
EPDC-1	FC	2013		920	-	-	-
Fukushima-1	RT	1998	BWR	439	1971	1971	1971
Fukushima-2	RT	1998	BWR	760	1974	1974	1974
Fukushima-3	RT	1998	BWR	760	1976	1976	1976
Fukushima-4	AFC	2004	BWR	760	1978	1978	1978
Fukushima-5	AFC	2003	BWR	760	1978	1978	1978
Fukushima-6	AFC	2006	BWR	1045	1979	1979	1979
Fukushima-II-1	AFC	2011	BWR	1045	1982	1982	1983
Fukushima-II-2	AFC	2010	BWR	1045	1984	1984	1985
Genka1-1	RT	1997	BWR	529	1975	1975	1975
Genka1-2	AFC	2009	BWR	529	1981	1981	1982
Hamaoka-1	RT	1998	BWR	500	1976	1976	1976
Hamaoka-2	AFC	2009	BWR	798	1978	1978	1978
Hokkaido-1	AFC	2016	PWR	550	1988	1989	1990

Table 2
OURE's June 1980 Nuclear Power Growth Projections
Japan (Continued)

<u>Reactor</u>	<u>Contract Type</u>	<u>Expiration Date</u>	<u>Reactor Type</u>	<u>Net MWe</u>	<u>Commercial Operation Date</u>		
					<u>High</u>	<u>Mid</u>	<u>Low</u>
Kyushu-5	AFC	2016	PWR	1140	1990	1992	1993
Senda1-2	AFC	2011	PWR	845	1988	1989	1990
Shikoku-3	FC	2014	PWR	1045	1991	1992	1993
Shimane-1	RT	1998	BWR	440	1974	1974	1974
Takahama-1	RT	1998	PWR	781	1974	1974	1974
Takahama-2	RT	1997	PWR	781	1975	1975	1975
Tahoku-4	AFC	2013	PWR	777	1992	1993	1994
Tohoku-5	FC	2015	PWR	777	1995	1995	1996
Toka1 Mura-2	AFC	2009	BWR	1045	1978	1978	1978
Tokyo-9	AFC	2011	BWR	1045	1985	1986	1987
Tokyo-10	AFC	2012	BWR	1045	1985	1985	1986
Tokyo-11	FC	2012	BWR	1045	1986	1991	1992
Tokyo-12	AFC	2016	BWR	1045	1989	1991	1992
Tokyo-14	AFC	2016	BWR	1045	1889	1993	1996
Tokyo-16	AFC	2017	BWR	1045	1990	1993	1996
Tokyo-19	AFC	2018	BWR	1045	1991	1994	1997
Tsurga-1	RT	2018	BWR	340	1970	1970	1970
Genka1-4	None	-	-	1140	1991	1993	-

Table 2

**OURE's June 1980 Nuclear Power Growth Projections
Japan (Continued)**

<u>Reactor</u>	<u>Contract Type</u>	<u>Expiration Date</u>	<u>Reactor Type</u>	<u>Net MWe</u>	<u>Commercial Operation Date</u>		
					<u>High</u>	<u>Mid</u>	<u>Low</u>
Hokkaido-2	AFC	2018	PWR	550	1990	1991	1992
Hokuriku-1	FC	2011	BWR	513	1989	1990	1991
Hokuriku-2	AFC	2018	BWR	798	1990	1993	1996
Hokuriku-3	FC	2015	BWR	808	1994	1996	1998
Ikata-1	AFC	2009	PWR	538	1977	1977	1977
Ikata-2	AFC	2011	PWR	538	1989	1991	1993
Tsuruga-2	AFC	2012	PWR	1102	1986	1988	1989
Kansai-1	AFC	2011	PWR	1116	1987	1988	1989
Kansai-2	FC	2012	PWR	1092	1988	1989	1990
Kansai-3	FC	2012	PWR	1092	1988	1990	1991
Kansai-4	AFC	2012	PWR	1116	1989	1990	1991
Kansai-5	AFC	2016	PWR	1092	1989	1993	1996
Kansai-6	AFC	2017	PWR	1045	1990	1994	1997
Mihama-1	RT	1998	PWR	320	1970	1970	1970
Mihama-2	RT	1998	PWR	470	1972	1972	1972
Mihama-3	RT	1997	PWR	781	1976	1976	1976
Namie Odaka-1	FC	2011	PWR	777	1990	1991	1992
Namie Odaka-2	AFC	2013	PWR	777	1991	1992	1993
Oh-1	RT	1997	PWR	1122	1979	1979	1979
Oh-2	RT	1997	PWR	1122	1979	1979	1979
Onagawa-1	RT	1998	BWR	500	1984	1985	1986

Table 3
OURE's June 1980 Nuclear Power Growth Projections
Kansai Electric Power Company

<u>Reactor</u>	<u>Contract Type</u>	<u>Expiration Date</u>	<u>Reactor Type</u>	<u>Net MWe</u>	<u>Commercial Operation Date</u>		
					<u>High</u>	<u>Mid</u>	<u>Low</u>
KANSAI-1	AFC	2011	PWR	1116	1987	1988	1989
KANSAI-2	FC	2012	PWR	1092	1988	1989	1990
KANSAI-3	FC	2012	PWR	1092	1988	1990	1991
KANSAI-4	AFC	2012	PWR	1116	1989	1990	1991
KANSAI-5	AFC	2016	PWR	1092	1989	1993	1996
KANSAI-6	AFC	2017	PWR	1045	1990	1994	1997
MIHAMA-1	RT	1998	PWR	320	1970	1970	1970
MIHAMA-2	RT	1998	PWR	470	1972	1972	1972
MIHAMA-3	RT	1997	PWR	781	1976	1976	1976
OHI-1	RT	1997	PWR	1122	1979	1979	1979
OHI-2	RT	1997	PWR	1122	1979	1979	1979
TAKAHAMA-1	RT	1998	PWR	781	1974	1974	1974
TAKAHAMA-2	RT	1997	PWR	781	1975	1975	1975

2) Discussions were held with Sales Support personnel at ORO. Marketing and contract data received from the utility indicated CODs of May 1984 for Unit-1 and March 1988 for Unit-2. However, the early date for Unit-1 was not believed to be realistic.

3) An examination of the EIA projections indicated a high/mid/low COD of 1986/1987/1988 for Unit-1 and 1987/1988/1989 for Unit-2.

4) Industry consultant projections put Unit-1 in the 1988-1989 time period and Unit-2 a year later.

5) The OURE high estimates of 1987 and 1988 were the earliest dates that it was felt the two units could be brought on assuming the above construction analysis lead times for Unit-1 and the utility information supplied to ORO for Unit-2. The mid and low estimates each assumed a one-year delay which places those estimates in line with EIA's and our industry consultant's estimates.

CODs for the remaining four Kansai units were developed using utility-supplied information for the high case and EIA/industry consultant information for the mid and low. We have not been able to uncover any literature information on the last four Kansai units.

The enrichment market for Japan is assumed to be totally captured by the United States through the early to mid-1990s. Japan has contracted with EURODIF for 10 million SWU with deliveries of 1 million SWU/year over the next 10 years scheduled. We expect this material to be used for stockpiling and to fuel reactors that might come on earlier than indicated in the DOE supply contracts. The only potential reactor included in the forecast to be supplied by DOE that is not currently under contract with DOE is Genkai-4 (the last reactor listed in Table 2). Genkai-4 was added as a result of OURE's last marketing trip to Japan. During that trip, Kyushu Electric Power representatives indicated that they would be seeking a DOE contract for Genkai-4 with the initial core delivery required in 1989. Since initial cores have usually been taken 2 to 3 years in advance of COD, we have assigned a high case COD of 1991 to the reactor. The uncertainty of need by the Japanese for additional enrichment supplies in light of their EURODIF contract and their plans to build their own enrichment facility caused us to assign a 1993

mid-case COD for Genkai-4. In the low case, Genkai-4 is assumed to receive enrichment services from non-U.S. sources.

QUESTION 18:

WHAT ARE THE PROBLEMS AND WEAKNESSES IN FORECASTING DEMAND AND PERFORMING MARKET SURVEYS?

The problems and weaknesses in our forecasting effort are listed below:

- 1) Obtaining accurate and timely data regarding the licensing and construction status of nuclear power plant projects. NRC information is fairly good for the U.S. projects; however, occasionally the data reported in the Yellow Book and Brown Book will be quite old yet not reflect that fact. Information for non-U.S. reactors is extremely hard to come by and, when available, must be compared with older data to make sure it is current. More information on foreign licensing procedures and status of plants in that process would be greatly helpful in developing better COD estimates for reactors currently planned.
- 2) Obtaining more information on the "real" reasons for reactor delays/cancellations. How much of the delays are really due to load growth versus regulatory problems. Is the regulatory excuse a simple out for other problems such as financial, local support, load growth, PUC, etc. Greater data in this area could impact estimates for other reactor projects in the same area or with the same utility.
- 3) Obtaining information on existing and planned utility stockpiles of enriched uranium and how those stockpiles will be utilized by the utility (or country).
- 4) Obtaining utility/country pooling plans and factor those impacts into demand projections.
- 5) Integrating the firm requirements under the AFC contracts into demand projections based on contract models.

6) Evaluating long-term use of reprocessing and the extent that recovered uranium and plutonium will be used as fuel for light water reactors. This could be particularly important for post-1990 non-U.S. demand. Currently, no response is assured during the planning period.

QUESTION 19:

HOW DOES OURE COVER THE FORECAST OF SUCH A LARGE MARKET WITH SUCH A SMALL STAFF?

OURE does not attempt to perform completely independent nuclear power growth forecasts based on electrical growth projections. We limit our effort to looking at currently available information regarding the status of nuclear projections and, where applicable, we correlate those findings with lead times developed by others such as NRC. We use information obtained by marketing staff through their monitoring of cables and participation in marketing missions. Originally, it was proposed to staff overseas offices, Tokyo, Brussels, and others, for monitoring market activities as well as servicing our current non-U.S. contracts.

We try to weigh outside analysis as reflected by EIA and consultants for reactor projects that have not started construction or have financial/load growth/regulatory problems that are not readily obvious. We utilize the expertise of sales support personnel at ORO to provide feedback concerning our estimates and make adjustments when appropriate. We have a review process within OURE that allows several people to examine and question, on a reactor-by-reactor basis, the final projections.

QUESTION 20:

HOW DOES OURE KNOW THAT 13,000 ENRICHMENT PEOPLE ARE BEING MANAGED WELL? HOW DO YOU MANAGE A SUPPORT CONTRACT (UCC AND GAT)? HOW DOES OURE MEASURE PERFORMANCE OF THE

ENRICHMENT ENTERPRISE? LIST THE GOALS AND OBJECTIVES, I.E., THE MEASURABLE AND CONTROLLABLE ONES. IN GENERAL, HOW DOES OURE KNOW THAT THE TWO OPERATING CONTRACTORS, UCC AND GAT, ARE BEING MANAGED WELL?

The Oak Ridge Operations Office has been delegated day-to-day management of the contracts with UCC and GAT. The OURE role in this respect is one of overview of the Oak Ridge Operations Office. The principal goals and objectives are established during the annual budget process. They include production levels and costs, progress on the CIP/CUP capacity expansion programs, process development goals, and expected progress on GPP and construction projects in the gaseous diffusion plant operations. Generally, major maintenance or procurements are singled out for special management attention. Currently, roof repairs to the major process building at all three sites and maintenance that was deferred because of interference with the CIP/CUP programs are being treated in this manner. Procurement of tails storage cylinders has been placed in a recurrent annual line item project. Monthly reporting procedures have been established to report on these goals and explain variances when goals are exceeded or not met.

Although the actual audit and appraisal of the contractor performance are carried out by the Oak Ridge Operations Office, the results are reported to OURE. In specialized areas such as safeguards and security and health and safety, Oak Ridge is overviewed by the DOE headquarters personnel from the Environmental and Safeguards/Security Offices ASEV and OSS. OURE is invited to participate in the final briefing on the results of these appraisals.

OURE is not staffed to appraise the contractor performance in all professional and business activities. The major control and measurement techniques used by OURE are the budget and planning systems and cost reporting mechanisms.

OURE has also attempted to evaluate "essential" employment levels at the gaseous diffusion plants. The uniqueness of the operation and the breadth and depth of activities carried out, particularly at Oak Ridge, do not permit handy rules-of-thumb to gauge manpower efficiency. We recently asked ORO to provide the impact on the operation of lower personnel levels. With the completion of the

technical phase of the CIP/CUP programs, we have initiated a long-term technical support program for the gaseous diffusion operations that would profitably maintain the unique technical skills needed to assure the reliability of the diffusion plants at least through the remainder of this century.

QUESTION 21:

DOES OURE HAVE SPECIFIC GOALS WHICH THE CONTRACT MUST MEET?

The operating contracts with Union Carbide and Goodyear do not spell out specific goals. Generally, the contracts run for a 5-year period; and, consequently, the contract calls for production goals established on a year-to-year basis. This procedure is consistent with the annual budgeting process under which we operate. Award fee performance evaluation standards are negotiated with Goodyear annually. The contracts do require the operating contractors to meet certain DOE and government standards on health and safety, cost accounting, procurement patents, employment practices, etc., without spelling out the criteria in detail.

QUESTION 22:

PROVIDE ALL AUDITS INVOLVING THE ENRICHMENT PROGRAM FROM THE LAST THREE YEARS BY GAO, ETC.

This question is answered through reference to several documents provided to the review group: Memorandum, June 9, 1980, to Mr. Thomas Beville; Memorandum, August 23, 1976, to Mr. Melvin Price; Memorandum, May 22, 1978, to Mr. Walter Flowers; Report by the Comptroller General of the United States: Nuclear Power Costs and Subsidies.

QUESTION 23:

WHAT IS THE IMPACT OF WEAPONS REQUIREMENTS UPON OURE'S SWU REQUIREMENTS? HOW DO WEAPONS REQUIREMENTS DRIVE THE DEMAND FOR SWUS?

Since 1964, no new enriched uranium has been produced for the weapons program. Enrichment planning has been driven by the civilian demand and efforts to capture the foreign market. Government requirements have been limited to existing and ongoing programs such as naval reactors, test reactors, and research reactors, and represent a small portion of cumulative demand.

Weapon scenarios that require new enriched uranium production have been treated as sensitivities to operating plans based on civilian demand as the driving force. This approach has been used with the understanding that weapons could not be used as a driving force until the demand or the contingency for such demand could be put on a firm basis.

If firm weapons demand or contingency for such demand should materialize, then this demand would replace the commercial market power reductions and timing/level of long-term operating tails assay increases. Large weapon demands, depending on the schedule need, could drive the timing of the last six buildings of GCEP as well as capacity additions after GCEP.

A high degree of confidence that a weapons demand might materialize would also drive the need for maintaining greater flexibility in GDP operations. This would increase the desirability of higher enriched natural uranium inventories and maintaining low (0.20-percent U-235) operating tails assays.

ISSUE ANALYSIS DIAGRAM

COMMENTS OF DR. RUTH M. DAVIS ON FOCUS OF STUDY

URANIUM ENRICHMENT
MANAGEMENT REVIEW

COMMENTS OF DR. RUTH M. DAVIS
ON FOCUS OF STUDY

The overall purpose of the review is to assist Dr. Ruth M. Davis, Assistant Secretary for Resource Applications, Department of Energy, in providing SOUND business advice to the Secretary of Energy on the financing, operation, and management of the Uranium Enrichment Program. The reason for requesting the review is not that current program managers have performed unsatisfactorily. The purpose of the review is to ensure that the program is sound from a business, management, financial, and operational point of view. The program is currently transitioning between very expensive technologies and more advanced technologies currently in the laboratory development phase, which are "breathing down our throats." Sound business judgments must be exercised in selecting the technology mixes, and managing the production complex in order to provide adequate program defense.

Dr. Davis indicated three key areas that the study group should focus on:

- I. Review Production Management Activities to Insure Good Production Management Techniques Are Being Utilized
 - Identify how new technology capacity should be phased-in (GDP versus GCEP versus AIS).
 - Can part of capacity be put into mothballs -- investigate cost of shutdown versus preproduction.
 - Factors in deciding to increase/decrease overall production, including lowest possible levels of production.
- II. Review Adequacy of the Models Utilized in Business Decision-making Process

Most management decisions are made based on old, well established but "creaky" models. Sensitivity of variables cannot be tested.

 - Would industry be willing to rely on these models?
 - Is update or replacement of these models appropriate?
- III. Market and Demand Forecasting to Assure Sound Planning Base for Production and "How to Live In" an Environment in Which Key Market Factors are Beyond Control of the Program
 - Suggest methods to assess international market.

- Consider impacts of export licensing and other factors that affect foreign supply commitments.
- Consider impact of Federal regulations on domestic market (safety, licensing, environmental, etc.)
- Assessment of how the international market can be predicted accurately - to match the need for GCEP or some new technology.

The study group should meet with the following individuals within the Department of Energy in addition to the enrichment personnel:

Dr. David Bodde, Policy and Evaluation - 202-252-5755
 Ted Ankrum, Conservation and Solar Energy - 202-252-9258
 Francis Allhoff, Under Secretary's Office - 202-252-6852
 Tony Cordesman/Jack O'Connor, Resource Applications'
 Policy and Planning Staff - 202-633-8362

Dr. Davis indicated that the study group should not waste time on:

- Budget cycle impacts on program
- Adequacy of requested funds to meet needs of program
- Organization of Department or program.

WHAT SHOULD URE DO TO ENSURE THAT SOUND BUSINESS JUDGMENTS WILL CONTINUE TO BE MADE IN MANAGING THE URANIUM ENRICHMENT PROGRAM?

WHAT SHOULD URE DO TO ITS PLANNING PROCESS TO BETTER REFLECT PRIVATE BUSINESS PRACTICES?

HOW DOES URE PREDICT ITS SWU REQUIREMENTS?

● How is foreign demand determined?

- How is the demand for nuclear power capacity estimated?
- How is foreign competition assessed?
- How are US international policies accounted for in demand forecasts?
- How are foreign countries' national policies assessed and accounted for in demand forecasts?

● How is domestic demand determined?

- How is the demand for nuclear power estimated?
- How is the competition of other fuels assessed?
- How is the technical performance of specific utility plants estimated?
- How are US national policies accounted for in demand forecasts?
- How are US military needs estimated?

● What SWU inventory is needed?

- How does URE set its inventory levels?
- What are the minimum and maximum inventories?

● How is new SWU demand resulting from marketing activities predicted?

- How quickly does URE move on new market opportunities?
- How can URE's marketing compete with competitors' marketing activities?
- How successful have previous marketing activities been?
- What are URE's competitive advantages?

HOW DOES URE DEVELOP A STRATEGY TO MEET ITS SWU REQUIREMENTS?

● What models are used and how are they used?

- What are the independent and dependent variables?
- What ranges in the variables are used within the models?
- What sensitivity analyses are produced and how are they used?

● What other information is used in developing production schedules?

- How are policy changes incorporated?
- How are budget changes incorporated?

● What contingency plans are developed?

● How are the flexibilities of the cascade facilities fully analyzed, in terms of minimum and maximum capabilities of the hardware, power availability and costs, and tails assay limits?

HOW DOES URE DEVELOP CAPACITY ADDITION PLANS?

● How does URE determine the readiness of new technologies?

- What information is gathered and from whom?
- What risk/regret analyses are conducted?

● How does URE justify a high level of excess capacity?

- For national security
- For foreign policy
- To meet contract uncertainties

● How does URE determine when it is time to retire existing cascade stages?

● What is the basis for new increments of capacity of 2.2 million SWU for GCEP?

HOW DOES URE ITS BUDGET?

● How does URE capital budget?

- Are long-range projections (greater than 10 years) developed?

● How does URE operating budget?

● How is the budget for the overall plant?

WHAT SHOULD URE DO TO ITS PRODUCTION MANAGEMENT PRACTICES TO BETTER REFLECT A PRIVATE BUSINESS OPERATION?

HOW SHOULD URE CHANGE ITS MANAGEMENT PRACTICES FOR NEW CAPACITY CONSTRUCTION?

● **Is the schedule for phasing in GCEP realistic?**

- How long would private industry take to bring GCEP into operation?
- How does URE's schedule compare with URENCO's?
- What are the flexibilities and constraints in the schedule?
- Have all potential delays been anticipated and have contingency plans been developed?

● **How are construction costs monitored and controlled?**

- Does URE employ an outside cost estimating firm and cost manager?
- What types of contracts have been established with design firms and vendors?
- What reporting systems are used to control costs?

● **How does policy changes and budget cuts affect the GCEP construction program?**

HOW SHOULD URE CHANGE ITS MANAGEMENT PRACTICES FOR THE GASEOUS DIFFUSION PLANT OPERATIONS?

● **How are operating costs controlled?**

- What incentive programs do UCC and GAT have to minimize costs?
- What is the average number of personnel needed to produce a SWU and how does it compare with EURODIFF?
- What reporting systems are used to predict cost overruns?
- What systems are used to evaluate the performance of line managers and what incentives do they have to control costs?
- What leverage does ORO have to substantially improve the efficiency of contractor operations?

● **How has the flexibility of the diffusion plants been evaluated?**

- What tests have been run on mothballing cascades?
- What tests have been run to determine the remaining useful life of the diffusion plants?
- What contingency plans exist for high fluctuations in SWU demand?

● **How can present policies for purchasing power be changed?**

- Can URE renegotiate its existing power contracts in light of reduced SWU demand?
- Should future power contracts be more flexible, even at a higher cost?

● **Are the auditing procedures similar to private business practices?**

- Does the accounting system include all overhead costs?
- Are there hidden costs to the government?

**WHAT FINANCING POLICIES SHOULD
BE CHANGED TO MAKE URE BETTER
REFLECT A PRIVATE BUSINESS ENTER-
PRISE?**

**SHOULD A REVOLVING FUND
BE USED?**

- What are the strengths and weaknesses of converting the financing of enrichment operations to a revolving fund basis?
 - Does the present budget approval process negatively impact the success of the URE program?
 - Would a revolving fund significantly help URE carry out its objectives?
 - Would the program be as responsive to policy changes under a revolving fund?

**HOW SHOULD THE SWU PRICE
BE SET?**

- Is a ten year rolling period appropriate to recover costs?
- Is the decision to purchase enrichment services from the US sensitive to price?
- Should URE set the price per SWU if a revolving fund were used?

Appendix B

THE NEED FOR STRATEGIC PLANNING

The Department of Energy's uranium enrichment enterprise is a major economic entity. Its annual sales would place it in the top half of Fortune magazine's list of the 500 largest American companies. In many ways it belongs on that list: it markets a valuable service for which it writes contracts and charges fees; it must by law finance its operations, investments, and some of its R&D with revenue from its sales; and it has competition from international suppliers.

The enterprise has much in common with the high-risk, high-technology, capital-intensive, private industries. The managers of OURE face a volatile market, rapidly changing production technologies, and multibillion-dollar capacity investments. Furthermore, they must time their investments to honor contracts and to retain market share. Finally, they must deal with the following facts:

- Worldwide civilian nuclear power forecasts vary widely and have changed drastically over the last few years, elevating capacity investments to a higher level of risk.
- Customers can cancel contracts, but OURE cannot because of possible adverse effects on the federal government's other activities with these organizations or countries.
- The Department of Energy no longer has a monopoly on enrichment services. URENCO, EURODIF, and the Soviet Union aggressively market their services and labor under fewer restrictions.

- Several advanced isotope separation technologies and the advanced gas centrifuge technology offer the promise of substantially lower cost SWU than the centrifuge plant now under construction. However, both performance and schedules of the advanced technologies are highly speculative.

To cope with this complex business environment, OURE must apply the most powerful ideas and effective tools available. Most appropriate to this environment is the modern, computer-assisted strategic business planning developed in the capital-intensive industries.

In addition to facing most of the difficulties of the high-risk private business, the enrichment enterprise is constrained in its actions as a public agency. It can devote only a limited amount of staff time to any activity because of budgeting and staffing limitations. Furthermore, it has many overseers in the Department of Energy, the administration, and Congress. Under these circumstances, OURE has a special need for a responsive, nonlabor-intensive, planning support system that will enable it to respond to the broad and diverse interests of its several overseers.

THE FUNCTIONS OF STRATEGIC PLANNING

Strategic planning has two basic functions. Its primary function is to propose a variety of significantly different, yet internally consistent business strategies for management's consideration. This serves to remind management that many alternatives exist and that better ways of conducting business and new considerations to influence the business are constantly emerging.

The second function of strategic planning is to predict the long-term results of pursuing alternative strategies. It should assess the many uncertain and uncontrollable factors affecting future results and provide management with a clear picture of the possible range and likelihood of the results of alternative strategies.

For example, strategies that have been generated and discussed by the review group include:

- The Department of Energy could overbuild capacity, underprice the service, market very aggressively, and attempt to drive some or all competitors from the market.
- The enrichment enterprise could be sold to private industry.
- Advanced isotope separation technology could be abandoned now and the resources shifted to the advanced gas centrifuge program, or vice versa.

Clearly there are other strategies and new options continually emerging. A formal strategic planning process will generate and evaluate these strategies and other quality options. The analytical tools are used to examine the implications to the business of any given option or sets of options.

For strategic planning to occur in an organization, a planning process must be developed and an organizational entity (such as a department or a committee) must be created to insure that the planning issues are dealt with at the proper level of management. To be effective, a planning organization, and the tools it uses, must focus on a clearly defined level of decisions. For example, in private industry, corporate planning does not work on production planning. Conversely, production planners are not involved in acquisitions and divestitures. Furthermore, all planners should concentrate on decisions that can, or must, be made in the near future. Planning a course of action five years from now is useful only to the extent that it helps make this year's decisions.

A planning organization must also have a clear understanding of the result measures that matter to its various stakeholders. Specific goals are not necessary, but planners must have a full set of measurable quantities on which to focus their predictive efforts. Technically, these result measures are the minimum set of factors that decision makers and overseers would want to know if they could foretell the future before making major decisions. (Generally, they should be expressible as

"yes" or "no" or as a number.) For example, the Department of Energy's European market share in 1985 (expressed as a percent of total kilograms of U₂₃₅ delivered) is a result measure only if a policymaker would be willing to invest to increase market share.

A complete list of result measures can only be compiled by interviewing a wide range of OURE's interested parties. However, a few possible result measures are:

- Annual cost flows to the government and the net present value of investment options
- Cost per kilogram of enriched uranium to the users
- Foreign market share, by
 - Region
 - Political bloc
 - Proliferation potential
- Energy consumed by the enrichment operation.

DEFINITION OF AN OURE PLANNING SUPPORT SYSTEM

The complex nature of OURE's environment requires that its planning efforts be centralized in one office and the staff supported by sophisticated computer tools. RPA therefore suggests that OURE centralize its strategic planning tools in one office operated by a single staff. The demand for Department of Energy enrichment services depends, to some degree on its price, which in turn depends on its production cost, and which ultimately depends on the level of capacity utilization. Consequently, the subjects of demand and production cannot be properly assessed separately. If the planning staff is centralized, it is easier to examine the combined effects of demand, production, pricing, and financial conditions.

While there is a strong need to keep OURE's planning system simple, it must, at the same time, be comprehensive. All the facets of OURE's business that affect its operating results must be dealt with and integrated. Without this integration, it is impossible to respond to or investigate the many inquiries that may arise.

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The model should be capable of both normal "deterministic" (point data estimates) and probabilistic operation. Probabilistic, or risk, analysis requires the ability to run a model innumerable times, sequentially, without manual intervention. Software for this type of operation is readily available, or can be easily written. However, model runs must be inexpensive to allow for the great number of runs sometimes involved in risk analysis. Technically, this is accomplished by suppressing the print-out of individual runs and by avoiding uncontrolled iteration whenever possible.

STRATEGIC PLANNING MODEL CONCEPT

The proposed strategic planning model consists of four component models, which have submodels. A flow diagram (see Exhibit B.1) illustrates the model concept. The intent of the strategic planning model is to provide comprehensive coverage of the important facets of the enrichment enterprise without developing extensive detailed models for each facet. The four component models are:

- Enriched uranium demand
 - Reactor data base
 - Department of Energy market share
 - Reactor conversion to enriched uranium demand
- Production cost
- Pricing
- Financial summary.

A brief description of each component model follows.

Exhibit B.1
Enrichment Enterprise Planning System

ENRICHED URANIUM DEMAND MODEL

Enriched Uranium Demand

Predicting the enterprise sales involves three submodels. Currently, most of the functions of these submodels are being carried out without computer aid. By applying computer-based tools to this function, three objectives will be achieved. First, a central repository for all demand data, which can be easily accessed and updated, will be created. Second, processing speed and computational accuracy will be attained. Third, a wide range of different demand conditions will be examined, either as scenarios or probabilistically, which will enhance the analysis of demand effects on production. Descriptions of the three submodels that perform these functions follow.

Reactor Data Base

This submodel would consist of a worldwide count of existing, planned, and forecast commercial reactors according to country, fuel cycle, size, capacity factor projections, refueling characteristics, on-line data, and measures of SWU price and contract term sensitivity. It would also include two probability estimates of reactor demand: the estimated date a reactor becomes operational and the estimate of sale or contract retention by the Department of Energy.

Department of Energy
Market Share

This submodel would store known information about SWU prices and contract terms for each Department of Energy competitor. For each reactor in the data base, it would compare each competitor's annual offering with that of the Department of Energy, and modify the initial probability of the department's sale or contract retention. Based on expected value of contract efforts, it would calculate the department's market share.

Reactor Conversion to Enriched Uranium Demands

This submodel would classify all existing reactors and all planned reactors with a probability of an operating date by generic fuel requirements, schedules, reactor size, and capacity factor. Each planned reactor, or existing reactor in need of fuel supply, would be evaluated and assigned a probability of sale by the department. The model would display probability distributions of enriched uranium demand plotted over time.

Production Cost

This model would simulate the use of a proposed configuration of enrichment facilities to meet the uncertain demand portrayed by the previously described models. Its principal outputs would be:

- The year-by-year future cost of operations
- Annual power requirements.

Unlike the EDIC model, the objective here would be to simulate how future enrichment enterprise managers will behave rather than to find the optimal least cost solution. The difference is that managers will always be uncertain about the future and will hedge their decisions accordingly. Algorithms for feed and product stockpile management and production level and tails assay decisions will be based on past experience. These algorithms will be applied to continuously unfolding scenarios in which the "present" demand and power and other operating and maintenance costs are known, but the "future" is always uncertain. Some of the inputs required by the production simulation model would be:

- Power requirement vs production level for each proposed facility
- Cost per kilowatt of power over time
- Capital cost for future facilities
- Initial feed and stockpile levels
- Year-by-year price projections for U_3O_8
- Fixed costs
- Discount and interest rates.

Pricing

The current OURE pricing formulas are applied directly to the cost output of the product cost model. The SWU production level multiplied by the price feeds into the financial summary model. The pricing model should feed back (with a year delay to avoid iteration) to the market space model to account for possible customer reactions to price changes. In addition, it should report any sudden price changes to the user and should have the capability for manual price change and price limits if OURE management deems this a political reality.

Financial Summary

This model collates results from the other models to summarize annual cash flows, costs to customers, power usage, market shares, and net present values. Using the data from the other models, it can calculate and print reports on any area of interest to policymakers. Moreover, it should be capable of generating reports at several levels of detail.

This model should be designed to minimize the amount of manual data manipulation required. It should be able to plot charts and graphs in formats directly understandable to policymakers. It is possible to use on-line visual scope displays and color graphics to expedite turnaround. Ideally, such models deliver results management can use immediately.

IMPLEMENTATION CONSIDER- ATIONS IN BUILDING THE STRATEGIC PLANNING MODEL

We have stated previously that the objective of the strategic planning model is to gain a comprehensive understanding of strategy options facing OURE. To accomplish this objective, the most effective model...

to use is a simple one. In meeting these standards of simplicity and comprehensiveness, we recommend that all of the models be built in five stages:

1. Calculate initial result measures using rough approximations and the least detailed inputs possible. (This is the pilot model.)
2. Conduct sensitivity analysis to determine the effect on result measures of variances in each input over the full error range of that input.
3. Apply the results of the sensitivity analysis to refine the model.
4. Continue to develop more detailed data and better approximations of the most sensitive factors. (Less sensitive areas can be left at the rough approximation level defined in the pilot model.)
5. Repeat the process until result measure uncertainty caused by each major input is approximately the same.

In addition, there are two other guidelines to model development. First, any factors that cause different strategies to be selected should be modeled more carefully than factors that do not have this effect. Second, approximation errors should not be reduced to a level far below the accuracy of the input data. For example, it is not practical to calculate the enriched uranium requirements of a reactor to within 0.5 percent in a pilot model if the number of reactors to be served varies by 15 percent.

RPA's experience also suggests that choice of staff in a model-building effort can be a major determinant of its eventual success. We suggest that the OURE staff that will eventually operate the model participate in its construction. The process of building a model is highly educational. It affords the opportunity to see the enterprise as a whole and to understand its interconnections. In addition, intimate knowledge of the model facilitates modifying it as circumstances and requirements change. In effect, the organization will understand the limits of the model's approximation and its range of applicability.

Consequently, it is often advisable to involve several individuals in the building effort to protect against future staff turnover.

Appendix C

REVIEW OF OURE STRATEGY STUDY*

The September 1980 Uranium Enrichment Strategy Study examines two broad areas of program decisions. First, it explores the issues of technology deployment, such as which technologies should be developed to produce SWU and at what capacity. Second, the study examines the area of operating plans to determine how the enrichment facilities can be operated most economically and reliably. Careful planning in both of these areas is critical to the success of OURE in accomplishing its objectives.

Because of the large financial impact and other long-term and irreversible implications of the technology deployment decisions, we will focus our discussion on a review of the technology deployment analysis. Capacity planning and technology deployment are critical to the success of the uranium enrichment program for a number of reasons. First, a major objective of the uranium enrichment program is to be a reliable supplier of SWU to every customer requesting these services from the U.S. government. As the only domestic supplier, this enterprise is critical to the U.S. nuclear power industry. As an international supplier, OURE is an important lever in executing the U.S. nonproliferation policy. The United States must have the capacity to meet all reasonable foreign requirements for uranium enrichment.

Second, the demand for enrichment services, particularly in the international market, is increasingly uncertain because of a variety of factors. Briefly, the social and economic impact of commitments to nuclear power are uncertain and may cause major policy shifts affecting total demand for SWU. Also, the increasing incidence of competition in the international market makes the United States market share more uncertain.

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Third, the lead time for capacity planning of the initial GCEP building is 8-10 years. However, contract deliveries are firmed up only 18 months in advance of delivery for requirements contracts, or 5 years for adjustable fixed commitment contracts. This adds to the uncertainty even in the domestic market. Exhibit C.1 shows a time line depicting the pace of major program decisions over the next 10-15 years.

Finally, the capital investments required for building enrichment facilities are substantial. For example, the estimated replacement cost for the existing gaseous diffusion process facilities is over \$15 billion. Possible commitment to such large capital investments must be carefully considered, as they will affect program performance for years to come.

Operating plans are also important because operating efficiency affects the cost of SWU and the total enterprise cost for enrichment customers. Operating and inventory policy can also affect the timing of the need for capacity. However, we will not focus our discussion on the operating plan because firm operating commitments, except power renegotiations, are made only 1 to 2 years in advance and can be revised periodically to respond to changing market conditions and new information on technology developments.

In the next section, we review OURE's analysis of technology deployment options. While the analysis appears to be generally sound and comprehensive, we have identified two areas where improvements would be helpful:

- Sensitivity analysis should be performed across the range of deployment strategies to permit clearer comparisons among strategies.
- The results measures used to evaluate strategies should include a clearer definition of "reliability" and should explicitly include near-term budget impact.

Then we will focus on a specific issue of the technology decision: Should GDP capacity be replaced by GCEP capacity? We will review the analysis of the replacement question performed by OURE.

Exhibit C.1
Timing of Decisions

THE TECHNOLOGY DEPLOYMENT DECISION

The September 1980 Uranium Enrichment Strategy Study presented three major recommendations and the analysis and reasoning behind those decisions:

1. Continue GCEP construction without further delay.
 - Completion of this project provides the greatest reliability for meeting higher than expected demand, and flexibility for future operating plans.
 - Based on discounted total enterprise cost, the GCEP program provides increasing economic benefits as levels of demand for enrichment services increase, and as the date of commercial availability of AIS technology is delayed beyond the early 1990s. It reduces the economic sensitivity to delays in AIS availability.
 - With operating experience gained from this program, technological improvements to gas centrifuge technology are highly likely to be developed and will provide greatly improved process economics.
 - If followed by successful development and deployment of AIS technology, completion of the full 8-building GCEP project promises the lowest total enterprise cost, most efficient operating levels, and greatest conservation of natural uranium and electric power.
 - Dependence on gas centrifuge technology, which is closer to commercial readiness, is less risky than dependence on AIS technology, which is in earlier development stages.
 - Completion of this project will provide a strong signal to customers, competitors, and potential competitors, of the U.S. commitment to be a reliable supplier of enrichment services.
2. Continue development of the advanced gas centrifuge technology.
 - It is likely that successive improvements of 50 percent, 75 percent, and 100 percent in the cost/performance of this technology can be achieved when compared to the existing (Set III) gas centrifuge technology.

- Achievement of such increases in technology performance would yield a lower total enterprise cost, lower energy consumption, and higher reliability of supply for the operation of the uranium enrichment facility.
 - Because of the expectation that only minor refinements in the technology are required to achieve the 50-percent performance improvement, the expected incremental cost of the additional SWUs from the development of the 50 percent improved technology (Set IV) is \$8 per SWU.
 - The advanced gas centrifuge technologies are closer to commercial deployment than the AIS technology.
3. Continue aggressive pursuit of AIS technology development.
- Given the present range of cost/performance projections for AIS technology, it is by far the lowest cost technology under consideration. Therefore, successful development and deployment of AIS technology promise reductions in the total enterprise cost, natural uranium and power consumption, and 30-year average cost of production.
 - Sensitivity analyses show that the sooner AIS can be deployed, the greater the economic benefits of AIS deployment and the less the program vulnerability to increases in demand.
 - This technology promises sufficient economic efficiency to make it feasible to "mine" tails inventory for conservation of natural uranium feed.

OURE used a sound businesslike approach to develop the technology deployment plan. They identified the major objectives of the program, identified alternative courses of action, and performed extensive quantitative analysis of the alternative plans under different assumptions about future events. Quantitative analysis was performed using the Equal Discounted Incremental Cost (EDIC) model, which is described in greater detail in Appendix B. The results of the analysis are discussed below.

Seven major quantitative factors and four qualitative factors were used to evaluate the technology deployment options. The quantitative factors were:

- Discounted total enterprise cost
- Discounted government cost
- Thirty-year average separative work cost
- Peak operating tails assay
- Peak requirements for natural uranium feed from the U.S. mining industry -- tonnage and date
- Year in which minimum enriched uranium inventory levels are reached
- Cumulative electric energy consumption by the enrichment facilities.

The four qualitative factors were:

- Reliability and flexibility to respond to future changes in demand and meet contractual commitments
- Technical viability and assurance of achievement
- International perception of the United States as a dependable supplier of enrichment services
- Political acceptability of strategy.

Throughout the remainder of this discussion, we will refer to the above factors as result measures. We will refer to factors that are important to the performance of the enrichment program and within the control of the government as strategy elements. We will refer to external factors, which significantly affect the performance of the enrichment program, but are beyond the direct control of the government, as scenario variables.

Exhibit C.2 shows the strategy elements considered in developing the program plans and the range of alternatives considered for each strategy element. Combinations of choices in each strategy element are strung together to form coherent strategies. Seven different strategies were considered. These are depicted graphically in Exhibits C.3-C.9. Exhibits C.3-C.6 show the four basic strategies considered and Exhibits C.7-C.9 show strategies

Exhibit C.2
Strategy Elements

CAPACITY DECISIONS			R&D DECISIONS			CONTRACT TERMS FOR POWER
GDP	GCEP/AGC	AIS	GDP	GCEP/AGC	AIS	
Maintain existing capacity	Build no capacity	Build no capacity	No further R&D	No further R&D	No further R&D	Advance notice for cancellation or reduction — 8 years TVA — 10 years EEI — 6 years OVEC
	Build 2 bldgs. retrofit with Set IV on present schedule (Total capacity: 3.4 million SWU)	Build as much capacity as soon as possible		Continue at present rate through Set IV, then stop	Continue at present rate	Extensions — require negotiations (TVA, OVEC) — OURE 3 year option (EEI)
	Build 8 bldgs., Set III on present schedule (8.8 million SWU by 1994); add Set III capacity as needed			Continue at present rate through Set VI		
	Build 8 bldgs.; retrofit bldgs. 1 and 2 with Set IV; fill bldgs. 3-8 with Set IV on present schedule (Total capacity: 13.8 million SWU by 1994)			Accelerate		
	Build additional AGC capacity as needed with best technology available					
	Build 8 bldgs. GCEP on accelerated schedule (Set IV) (Total capacity: 13.8 million SWU by					

Exhibit C.3
Strategy No. 1
GDP + GCEP Set III + No R&D

STRATEGY ELEMENTS CONSIDERED

Exhibit C.4

Strategy No. 2
GDP + GCEP Set IV + AGC R&D

STRATEGY ELEMENTS CONSIDERED

Exhibit C.5
Strategy No. 3
GDP + GCEP Set IV + AIS

STRATEGY ELEMENTS CONSIDERED

Exhibit C.6
Strategy No. 4
GDP + AIS

STRATEGY ELEMENTS CONSIDERED

Exhibit C.7
Strategy No. 5
GDP + 2 bldg GCEP Set IV + AIS

STRATEGY ELEMENTS CONSIDERED

Exhibit C.8
Strategy No. 6
GDP + 2 bldgs GCEP Set IV +AGC R&D

STRATEGY ELEMENTS CONSIDERED

Exhibit C.9
Strategy No. 7
GDP + Accelerated GCEP Construction + AIS

STRATEGY ELEMENTS CONSIDERED

considered in sensitivity analyses. Basic descriptions of these seven strategies are as follows:

- Strategy 1: Operate GDP, build 8 buildings GCEP (Set III), and cease development of advanced technologies.
- Strategy 2: Operate GDP, build 8 buildings GCEP (Set IV), and continue development of advanced gas centrifuge.
- Strategy 3: Operate GDP, build 8 buildings GCEP (Set IV), and develop and deploy AIS as soon as possible.
- Strategy 4: Operate GDP, cease development of gas centrifuge technology, and develop and deploy AIS as soon as possible.
- Strategy 5: Operate GDP, build 2 buildings GCEP (Set IV), and develop and deploy AIS as soon as possible.
- Strategy 6: Operate GDP, build 2 buildings GCEP (Set IV), and cease development of AIS technology.
- Strategy 7: Operate GDP, accelerate construction of 8 buildings GCEP (Set IV), and develop and deploy AIS as soon as possible.

A number of important external factors that affect the enrichment program performance were identified in the planning process. The two most significant were the level of demand (domestic and foreign) for U.S. enrichment services and the commercial availability date of AIS production capacity. Exhibit C.10 shows the scenario variables and ranges that were considered in the analysis. Combinations of values for each scenario variable are strung together to form logical scenarios. Exhibits C.11 through C.34 show the 24 scenarios used in the analysis.

Four basic scenarios were considered. They are depicted as Scenarios 1 through 4, in Exhibits C.11-C.14, and incorporated two assumptions of demand levels in the year 2000, 250 GWe, or 350 GWe, and 2 possible commercial availability dates of AIS, 1990 or 1995. The other 20 scenarios were used in sensitivity analyses.

Exhibit C.10
Scenario Variables

Power Availability	Restrictions On GDP Power Consumption	Real Power Cost	Nuclear Power Generation Served by DOE in Year 2000	GCEP/AGC On-Line	GCEP/AGC SWU Cost (\$1980/SWU)	AIS On-Line	AIS SWU Costs (\$1980/SWU)	Sell Enriched Tails	Real Uranium Price	New Capacity Deployment (Million SWU/yr ²)	
										AIS	AGC
7060 MW Total	Minimum 2200 MW; no upper restriction	\$23 mils/kWh + 3%/yr. 1981-1990; +1.5%/yr. 1991-2010	208 GW _e by 1993, then constant	Set III 1985 Set IV 1989 Set V 1993 Set VI 1996	Set III 88 Set IV 59 Set V 51 Set VI 45	1990	X	No	\$100/kg	4.4	2.2-2.9
						1993	2X throughout	Yes, but limit to 50% of excess over 23 million tons mined	\$115/kg +1.0%/yr.	6.6	4.4
	Minimum 2200 MW; upper limit 4500 MW from 1986 through planning period	\$23 mils/kWh + 5%/yr.	250 GW _e			1995	5X 1990 decreasing to X by 1995		\$115/kg +1.5%/yr.	8.8	6.6
		\$35 mils/kWh constant 1981-2010	350 GW _e			1997	2X 1990 decreasing to X by 1995	Yes, but limit to 50% of excess over 16.5 million tons mined			8.8

Exhibit C.11
Scenario 1
250 GW_e Demand, 1990 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.12
Scenario 1a
250 GW_e Demand, 1993 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.13
Scenario 1b
250 GW_e Demand with Sensitivity to Real Power Cost

SCENARIO VARIABLES CONSIDERED

Exhibit C.14
Scenario 1c
250 GW_e Demand with Restrictions on GDP Power Consumption

SCENARIO VARIABLES CONSIDERED

Exhibit C.15
 Scenario 2
 250 GW_e Demand, 1995 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.16
Scenario 2a
208 GW_e Demand Sensitivity

SCENARIO VARIABLES CONSIDERED

Exhibit C.17
Scenario 2b
250 GW_e Demand, 1977 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.18
 Scenario 2c
 250 GW_e Demand with High Power Cost Escalation

SCENARIO VARIABLES CONSIDERED

Exhibit C.19
Scenario 2d
250 GW_e Demand with Restrictions on GDP Power Consumption

SCENARIO VARIABLES CONSIDERED

Exhibit C.20
Scenario 3
 350 GW_e Demand, 1990 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.21
Scenario 3a
350 GW_e Demand, No Sale of Enriched Tails

SCENARIO VARIABLES CONSIDERED

Exhibit C.22
Scenario 3b
350 GW_e Demand, 1993 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.23
Scenario 3c
350 GW_e Demand with Sensitivity to AIS SWU Costs

SCENARIO VARIABLES CONSIDERED

Exhibit C.24
Scenario 3d
350 GW_e Demand with Sensitivity to AIS/SWU Costs

SCENARIO VARIABLES CONSIDERED

Exhibit C.25
 Scenario 3e
 350 GW_e Demand with Sensitivity to AIS SWU Costs

SCENARIO VARIABLES CONSIDERED

Exhibit C.26
Scenario 3f
350 GW_e Demand with Sensitivity to Real Power Cost

SCENARIO VARIABLES CONSIDERED

Exhibit C.27
Scenario 4
350 GW_e Demand, 1995 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.28
Scenario 4a
350 GWe Demand with 6.6 Million SWU/yr² AIS Deployment Rate

SCENARIO VARIABLES CONSIDERED

Exhibit C.29

Scenario 4b

350 GW_e Demand with 8.8 Million SWU/yr² AIS Deployment Rate

SCENARIO VARIABLES CONSIDERED

Exhibit C.30
Scenario 4c
350 GW_e Demand with 4.4 Million SWU/yr² AGC Deployment Rate

SCENARIO VARIABLES CONSIDERED

Exhibit C.31

Scenario 4d

350 GW_e Demand with 6.6 Million SWU/yr² AGC Deployment Rate

SCENARIO VARIABLES CONSIDERED

Exhibit C.32
Scenario 4e
350 GW_e Demand with 8.8 Million SWU/yr² AGC Deployment Rate

SCENARIO VARIABLES CONSIDERED

Exhibit C.33
Scenario 4f
350 GW_e Demand, 1977 AIS Availability

SCENARIO VARIABLES CONSIDERED

Exhibit C.34
Scenario 4g
350 GW_e Demand with Sensitivity to Sale of Enriched Tails

SCENARIO VARIABLES CONSIDERED

Each of the four base strategies was analyzed against each of these four base scenarios. The results of this analysis are depicted in strategy comparison tables (Exhibits C.35 and C.36). (This exhibit simply reorganizes information presented in Table V-3 of the strategy study.) The strategy comparison table permits direct comparison of quantitative results measures for different strategies under different scenarios.

Minimization of total enterprise cost is a major objective function of the EDIC model and is the most important quantitative criterion for the enrichment program. Exhibit C.37 shows a simplified strategy comparison table that includes only total enterprise cost and a rank for each strategy under each scenario.

From this table, we see that Strategy 4 is the most favorable (GDP and cancel GCEP and develop AIS) at the lower demand, or if AIS can be commercialized by 1990. However, if demand is high and AIS is not available until 1995, then Strategy 3 is best, and Strategy 2 is also superior to Strategy 4. Both Strategies 2 and 3 include continuation of the GCEP project and further development of either AGC or AIS, respectively.

Under each of the four base scenarios, Strategies 2, 3, and 4 were all within 3 percent of one another when measured by a 30-year discounted total enterprise cost. When considering the uncertainty inherent in the demand forecasts, power cost assumptions, and other important variables, a 3-percent difference in 30-year total enterprise cost could hardly be conclusive.

However, the sensitivity analysis represented by Scenario 15 (Exhibit C.25) shows that if demand is high and AIS is not available until 1997, the economic penalty for pursuing Strategy 4 grows rapidly. From Table V-8 of the strategy study, we find that the total enterprise cost associated with Strategy 4 under this scenario is 4 percent higher than the scenario with AIS in 1995.

Without completion of GCEP, the program economics become highly sensitive to the commercialization date of AIS. Also note that both Strategies 3 and 4, which include development of AIS, are preferred over Strategies 1 and 2, which terminate development of AIS.

**Strategy Comparison Table
Scenarios 1 and 2**

Base Strategies	Base Scenarios	
	(1) 250 GWe Demand, 1990 AIS Availability	(2) 250 GWe Demand, 1995 (or Never) AIS Availability
1. GDP + 8 bldgs GCEP (Set III) + No R&D		
a.		56.90
b.		20.04
c.		170
d.		33,700
e.		75.13
f.		1988
g.		0.225
2. GDP + 8 bldgs GCEP (Set IV) + AGC R&D		
a.		54.72
b.		18.37
c.		138
d.		23,400
e.		56.32
f.		1991
g.		0.20
3. GDP + 8 bldgs GCEP (Set IV) + AIS R&D		
a.	52.91	53.97
b.	17.96	17.55
c.	109	132
d.	22,100	22,900
e.	38.32	48.28
f.	1988	1993
g.	0.20	0.20
4. GDP + AIS Soonest + AIS R&D + Cancel GCEP		
a.	51.35	53.61
b.	15.65	15.95
c.	125	164
d.	22,600	24,300
e.	41.56	55.74
f.	1990	1995
g.	0.195	0.26

- a. Discounted Total Enterprise Cost (\$ x 10⁹)
b. Discounted Total Government Cost (\$ x 10⁹)
c. GDP Energy Usage (GWe/yr)
d. Peak Uranium Requirement (MTU/yr)

- e. 30-yr Average Cost (\$/SWU)
f. Year Minimum Stockpile Reached
g. Highest Fails Assav (%)

**Strategy Comparison Table
Scenarios 3 and 4**

Base Strategies	Base Scenarios	
	(3) 350 GWe Demand, 1990 AIS Availability	(4) 350 GWe Demand, 1995 (or Never) AIS Availability
1. GDP + 8 bldgs GCEP (Set III) + No R&D		
a.		75.31
b.		24.42
c.		199
d.		70,600
e.		77.27
f.		1995
g.		0.315
2. GDP + 8 bldgs GCEP (Set IV) + AGC R&D		
a.		70.69
b.		21.49
c.		190
d.		48,700
e.		61.28
f.		1993
g.		0.24
3. GDP + 8 bldgs GCEP (Set IV) + AIS R&D		
a.	67.01	69.25
b.	19.78	19.93
c.	132	178
d.	34,000	43,300
e.	40.62	52.77
f.	1990	1993
g.	0.19	0.24
4. GDP + AIS Soonest + AIS R&D + Cancel GCEP		
a.	66.27	70.89
b.	17.78	19.72
c.	162	206
d.	34,700	53,400
e.	45.10	59.70
f.	1991	1995
g.	0.21	0.375

- a. Discounted Total Enterprise Cost (\$ x 10⁹)
b. Discounted Total Government Cost (\$ x 10⁹)
c. GDP Energy Usage (GWe/yr)
d. Peak Uranium Requirement (MTU/yr)

- e. 30-yr Average Cost (\$/SWU)
f. Year-Minimum Stockpile Requirement
g. Highest Tails Assay (%)

Exhibit C.37

**Strategy Comparison Table
Total Enterprise Cost and Rank**

Base Strategies	Base Scenarios				Average Rank
	① yr 2000 demand 250 GWe AIS-1990	② yr 2000 demand 250 GWe AIS-1995 (or never)	③ yr 2000 demand 350 GWe AIS-1990	④ yr 2000 demand 350 GWe AIS-1995 (or never)	
① GDP + 8 bldgs. GCEP Set III + No R&D		\$56.90 billion ④		\$75.31 billion ④	4.00
② GDP + 8 bldgs. GCEP Set IV + AGC R&D		\$54.72 billion ③		\$70.69 billion ②	3.50
③ GDP + 8 bldgs. GCEP Set IV + AIS R&D	\$52.91 billion ②	\$53.87 billion ②	\$67.01 billion ②	\$69.25 billion ①	1.75
④ GDP + Cancel GCEP + AIS R&D	\$51.35 billion ①	\$53.61 billion ①	\$66.27 billion ①	\$70.89 billion ③	1.50

Exhibit C.38 shows another simplified strategy comparison table, this time for the variable peak natural uranium feed requirement. Strategy 3 is the most attractive strategy under each scenario when measured against the goal of minimizing natural uranium consumption. For this variable, however, the differences among Strategies 2, 3, and 4 are more pronounced. Under Strategy 4 (cancel GCEP) at high demand and late availability of AIS, the peak feed requirement could strain capacity of the uranium mining industry, thereby adversely affecting the U.S. position as a reliable supplier of enriched uranium.

Additionally, Strategy 1 is inferior to Strategy 2 under all scenarios (see Exhibits C.37 and C.38). The only difference between these strategies is that Strategy 2 includes development of advanced gas centrifuge technologies beyond Set III. This indicates that, given Set III, there is always an economic benefit from development of AGC technology.

Exhibits C.37 and C.38 support the major decisions of the strategy study, as described earlier in this appendix:

1. Continue GCEP without further delay. With high demand levels and delays in AIS development,* GCEP is attractive in terms of its economics and reliability (e.g., it will minimize strain on the uranium mining industry). At lower levels of demand, pursuing this course results in only slightly higher costs than cancelling it and developing AIS alone. Thus, the decision is made to risk slightly higher costs at lower demand levels in order to be able to respond reliably and economically to higher demand levels.
2. Continue development of the advanced gas centrifuge technology. There is a clear economic benefit from this technology, given the decision to pursue GCEP.
3. Continue aggressive pursuit of AIS technology. If it can be commercialized with the current cost/performance characteristics, developing it along with GCEP/AGC will result in a lower total enterprise cost than developing only GCEP/AIS. If GCEP were reduced or cancelled, the total enterprise cost and reliability would be quite sensitive to the availability date of AIS technology.

Exhibit C.38

**Strategy Comparison Table
Peak Natural Uranium Feed Requirement and Rank**

Base Scenarios					
Base Strategies	① yr 2000 demand 250 GWe AIS-1990	② yr 2000 demand 250 GWe AIS-1995 (or never)	③ yr 2000 demand 350 GWe AIS-1990	④ yr 2000 demand 350 GWe AIS-1995 (or never)	Average Rank
① GDP + 3 bldgs. GCEP Set III + No R&D		33,700 ④		70,600 ④	4.0
② GDP + 3 bldgs. GCEP Set IV + AGC R&D		23,400 ②		48,700 ②	2.0
③ GDP + 3 bldgs. GCEP Set IV + AIS R&D	22,100 ①	22,900 ①	34,000 ①	43,300 ①	1.0
④ GDP + Cancel GCEP + AIS R&D	22,600 ②	24,800 ③	34,700 ②	53,400 ③	2.5

REVIEW OF OURE STRATEGY

Exhibit C.39 is a strategy comparison table (the results have been purposely omitted) that represents both the base case and sensitivity analyses reported by OURE. The 7 strategies and 24 scenarios are listed. The shaded areas show the analyses for results that were reported in the strategy study. For most of the sensitivity analyses, only 1 or 2 strategies were tested against a new scenario.

While OURE has performed a comprehensive analysis of technology deployment options, we feel that there are two areas where further improvements are needed. First, as indicated in Exhibit C.39, many of the scenarios were analyzed for only one or two different strategies. Direct comparison of the strategy alternatives would have been facilitated by presentation of the analysis of all strategies against any particular scenario. When a sensitivity analysis has identified those scenario variables that have important effects on the program performance, it is then possible to identify strategies that reduce the sensitivity of the program performance to the individual uncontrollable factors. For example, the comparison of the four basic strategies against the four basic scenarios showed that the program performance was highly sensitive to the date of AIS availability if the GCEP program is terminated, and that the sensitivity to AIS availability date could be considerably lessened by the completion of the GCEP program. Therefore, completing the analysis of each strategy against the other sensitivity scenario variables could have shown other areas where sensitivity of the program performance to uncontrollable future events could be lessened through present strategic choice.

Secondly, the results measures used to evaluate strategies should explicitly include near-term budget impact and a clearer definition of reliability of supply. The former factor seems to be of considerable importance to top management at the Department of Energy. Of the seven quantitative measures, three dealt with cost. It would appear relatively straightforward to include a fourth cost measure related to short-term budget effects, e.g., "capital outlays required over the next three years." The importance of supply reliability and flexibility to respond to changing demand in the technology deployment choice suggests that OURE should attempt to develop an objective measure of reliability. This would be an improvement over the present qualitative treatment of the measure in the narrative of the strategy study. For example, while

[illegible]

Scenarios

REVIEW OF OURE STRATEGY

it may be obvious that one deployment strategy offers more reliability and flexibility than another, it is difficult at present to discern the risk inherent in the less reliable strategy.

Some of the quantitative measures (e.g., year minimum stockpile reached) are indirect indicators of reliability. A more direct measure is probability of not meeting total demand. Short of this, several indirect measures could be combined to create an objective reliability index.

ANALYSIS OF REPLACEMENT OF GDP CAPACITY WITH GCEP CAPACITY

An important mandate of the enrichment program is to be a reliable supplier of SWUs to meet all possible demand. Therefore, OURE cannot permit undercapacity for an extended period of time. Given the present forecasts, GCEP capacity will be needed to meet increases in demand that present GDP capacity cannot meet.

However, it is possible that completion of the full eight buildings of GCEP, and retrofit with the Set IV technology, may result in significant overcapacity if demand levels do not reach present estimates. In light of this, the strategy study included an analysis of the comparative cost of GDP and GCEP under different assumptions of future power cost. The analysis of the possible replacement of GDP with GCEP capacity yielded the following conclusions:

- GCEP (Set III) is increasingly attractive as a replacement for GDP capacity as real power costs escalate because of its 20-to-1 reduction of power consumption.
- At moderate estimates of power cost growth (specifically, above 3 percent per year real power cost growth), GCEP (Set III) would economically replace GDP capacity (at a projected cost of \$88/SWU).
- Successful development of the advanced gas centrifuge would dramatically increase the incentives to replace the GDP capacity with gas centrifuge capacity.

- It would be unwise to shut down any GDP capacity before commercial operating experience with GCEP is achieved.
- Long-term power commitments offer some cost constraints to the speed and timing of GDP shutdown decisions.

We feel that the presentation of the GCEP/GDP analysis understated the expected economic and other benefits of replacing GDP with GCEP.

OURE should consider revising its analyses to reflect more accurately the economics of the choice between GDP and GCEP. The present approach is unfavorable to GCEP because it includes both sunk costs and costs of Set IV technical development, which should be excluded.

For example, if OURE were to decide today whether or not to continue GCEP as the only replacement for GDP capacity, it should not include previously incurred construction or other costs in the investment analysis. These sunk costs will be recovered in any event. However, the GCEP/GDP analysis includes sunk costs (e.g., imputed interest on prior investment) as part of GCEP costs.

Additionally, future GCEP costs in the analysis include the full development costs of Set IV technology. The analysis that arrived at the \$88/SWU cost assumes only Set III technology. Thus, the analysis should not have included any Set IV development costs. If Set IV development costs are included, then some expected benefit (i.e., cost reduction) should also be included. It appears highly likely that Set IV will reduce costs considerably. Thus, the \$59/SWU figure that OURE computed assuming Set IV technologies is perhaps a closer approximation of the expected centrifuge cost and should be used in evaluating replacement of GDP with GCEP.

Other factors can be considered important in making this decision. In the face of increasing competition in the international market, construction of GCEP helps OURE maintain technological and cost leadership in the increasingly competitive marketplace. Also, pursuit of GCEP offers a strong signal to both customers, competitors, and potential competitors, of the U.S. long-term commitment to meeting enrichment demand. This is important in the marketing of enrichment services as described in the findings of the review group.

Appendix D

AN APPROACH TO ASSESSING FOREIGN ENRICHMENT REQUIREMENTS

Because it is U.S. policy to be a reliable supplier of enriched uranium and to meet the needs of all customers, the United States must have sufficient enrichment capacity to meet demand. Given the high cost and long lead time associated with capacity expansion, demand forecasting is an important component of OURE's planning effort.

To enable OURE to consider the dynamics of the foreign enrichment market more comprehensively, and perhaps to develop probabilistic estimates of the likelihood of U.S. success vis-a-vis its competitors, this appendix discusses an approach to competitive analysis that is becoming widely accepted in industry. As we will note, OURE is already performing portions of this analysis. We will identify additional steps for OURE to take to develop a more comprehensive forecasting analysis.

There are two broad types of competitive forces that should be analyzed: threat of new entrants and rivalry among existing competition.

THREAT OF NEW ENTRANTS

New entrants to an industry bring new capacity, desire to gain market share, and often substantial resources. They may be willing to gain market share at the expense of profitability, thereby reducing prices in the short or over the long term. The threat of entry into an industry generally depends on the barriers to entry that are present, coupled with the reaction from existing competitors that the entrant can expect. There are significant barriers to entering the uranium enrichment business, primarily related to capital investment requirements, economies of scale, and lack of access to cost-effective

enrichment technologies. While these barriers are probably sufficient to keep any individual private company from entering this field, they may not deter countries who deem it in their national interest to be a producer of enriched uranium.

For example, countries that are or may become heavily dependent on nuclear power may decide for national security reasons to develop an internal enrichment production capacity, in order to become less reliant on other nations. Japan, Brazil, and Australia are currently considering developing an internal enrichment capacity, and it is important that OURE analyze the factors that will cause them to develop an internal capacity, as well as those factors that might weigh against the decision. This may allow OURE to take some steps in order to deter new entrants.

RIVALRY AMONG EXISTING INDUSTRY PARTICIPANTS

The relatively recent emergence of EURODIF and URENCO, coupled with the presence of the U.S.S.R. as a producer of enriched uranium, is likely to lead to intense rivalry as these participants and the United States seek to maximize their market share. For both political and economic reasons it is in the interest of each competitor to utilize the enrichment production capacity to the fullest extent practicable. However, at the present time the future growth of the nuclear power industry and thus of the demand for enriched uranium, is highly uncertain. Projections of future demand have been declining each year, and the future of nuclear power is uncertain. The United States is currently using only about half of its total enrichment production capacity, but is nevertheless installing 2.2 million SWU of new capacity by the early 1990s. Thus, it is conceivable that the overcapacity situation will continue indefinitely. With this condition existing among the various industry competitors, it is likely that there could be intensive competition to maximize market share and capacity utilization. (Selective price cutting is apparently taking place now.) Thus, it is necessary that OURE fully understand what factors motivate its competitors and what strategic moves competitors are likely to make in the future.

While OURE is aware of its competitors and of their general strategic direction, a more comprehensive understanding of potential competitors (i.e., new entrants) and existing competitors would help OURE in two important ways. First, it would facilitate a more reliable assessment of the U.S. share of the foreign enrichment market. That is, with better information on likely competitor strategies and actions and existing information on customer preferences and relative U.S. strengths and weaknesses, OURE could compile a better assessment of the likelihood of the United States obtaining specific foreign enrichment contracts. This more careful assessment of the uncertainty surrounding foreign market share would be a direct input to the proposed probabilistic demand forecasting model.

Beyond providing better information on enrichment demand, the competitor analysis will enable the United States to modify its own strategy (within the limits imposed by law) to gain maximum competitive advantage in the enrichment market. With a systematic review of likely competitor strategies and an analysis of the implications of those strategies, OURE may conclude that specific actions related to marketing, production, and pricing should be taken in order to preserve or increase market share.

In the next section, we discuss a framework for analyzing the competition and a competitor intelligence system that will be required to provide the necessary data for the analysis.

COMPETITIVE ANALYSIS FRAMEWORK

The objective of the analysis is to develop for existing and potential competitors a profile of the nature and success of competitor strategies; in addition there are likely strategy changes that each might make, each competitor's likely response to the range of strategic moves that other competitors could initiate, and each competitor's reaction to a range of industry changes and broader environmental changes that might occur. The analysis also provides insights into the relative bargaining power of competitors vis-a-vis customers. The competitor profiles should be constructed on at least two.

levels: an individual profile for each country or region where the competitor is or may be active, and then a general profile for the competitor's business as a whole.

The suggested competitor analysis has the following four components:

1. Diagnosis of competitors' objectives
2. Identification of each competitor's assumptions
3. Documentation of competitor's current strategy
4. Identification of each competitor's strengths and weaknesses.

In each of these four areas, we present a representative set of specific questions that should be answered for the competitors. At least some of the questions could probably be answered now, based on the knowledge contained within OURE. The value of the framework and the questions is that they allow OURE to systematically and consistently evaluate competitors and to document the evaluation in writing. (OURE should prepare a more comprehensive and specific set of questions before actually undertaking the analysis.)

Diagnosis of Competitors' Objectives

Diagnosing competitors' objectives would allow OURE to make projections about whether or not each competitor is satisfied with its present position, and how it might react to strategic changes. For potential entrants, OURE would be able to determine if and when a country may develop enrichment capability. The diagnosis provides answers to a number of questions, including:

1. What are the national objectives of the sponsor countries of each competitor?

The strategy of each competitor will be closely linked to the objectives of the sponsor countries. It is important that OURE understand and document the goals and objectives of each sponsor country, both for existing competitors and

potential new entrants (e.g., Japan). Examples of such objectives are:

- To become less dependent on outside suppliers of enriched uranium, either the United States or others
- To gain leverage or influence by becoming the preferred supplier of enriched uranium to other nations
- To improve balance of payments position.

In assessing the objectives of the sponsor countries, OURE should also attempt to discern the relative strengths of each sponsor; this may be an indication of the relative importance of each sponsor's objectives, in terms of the actual strategy and operation of the competitor.

2. What are the competitors' financial objectives?

OURE should document the stated and unstated financial objectives of each competitor. For example, is the competitor trying only to recover its costs, as in the case of the United States? Or does it attempt to earn a profit? Is the sponsor government willing to subsidize a loss if this would help in attaining market share objectives? What financial constraints exist? And what are the implications for capital investments and other expenditures in both the short and long term?

3. What are the competitors' market share objectives?

Beyond satisfying the SWU requirements of sponsor countries, what other markets is the competitor likely to pursue? Why? Does there appear to be any one country or region that is a particularly high market priority for the competitor? It is likely that the answers to these market questions will be closely linked to the assessment of the country's political goals, as discussed above.

4. What are the technology objectives?

Is the competitor striving to be an industry leader in terms of technology, or is it willing to use available but perhaps less efficient technology? Does the competitor appear to be willing to invest significantly in the development of new enrichment technologies? What are the R&D expenditures, and how can these be linked to the

technology objectives? What are the current technologies being used by the competitor and how do they compare with others in the industry? Does the competitor or its sponsor countries appear likely to have the financial resources to invest heavily in both R&D and the capital cost required of new enrichment technologies, such as GCEP?

The answers to these questions about competitor objectives and those listed for the other components of the analysis may not be readily available in published form, given the relative lack of public information about OURE's foreign competitors. In the next section, which addresses a "competitor intelligence system," we suggest possible information sources relevant to the questions. In many cases, the answers will derive from the judgment of OURE management and staff formed during marketing trips and staff meetings. These judgments are important because they are based on an in-depth understanding of the industry. Documenting these judgments, in response to specific questions, is crucial to the competitive analysis.

Identification of Each Competitor's Assumptions

The purpose of this component of the analysis is to identify each competitor's assumptions about itself and about the industry and other players in it. As with the competitor's objectives, the considered judgment of OURE's staff may be required here, given the lack of published information in this area. Understanding competitors' assumptions about the industry will provide indications of the strategic moves that a competitor might make. The following questions will help to categorize the important assumptions to be documented:

1. What does the competitor appear to believe about its own relative position in the industry? What does each competitor assume about its own relative market share, production costs, SWU price, degree of technological sophistication? Do these beliefs appear to be accurate?
2. What does each competitor appear to believe about future SWU demand? Both in its own country and worldwide, what assumptions might the competitor be making about the future of nuclear power? And about the preferences of existing or potential customers?

3. What does the competitor appear to believe about the goals and capabilities of its competitors? For example, with regard to the United States, does the competitor appear to be making the right assumptions about current or future U.S. plans and strategies in uranium enrichment? Does the competitor understand the U.S. foreign market objectives? Does the competitor understand the current overcapacity situation that exists in the United States? Does the competitor understand the implications of U.S. pricing and other contract terms, relative to its own terms or those of other competitors?

Documentation
of Competitor's
Current Strategies

Documenting the competitor's strategy involves identifying the key operating policies and procedures in each functional area, including: marketing and sales, manufacturing, research and development (R&D), and finance and control. The following is a representative list of specific information that should be sought in each of these areas:

- Marketing and sales
 - Organization, size, and techniques of sales force
 - Pricing policy
 - Contract terms
 - Cancellation charges
 - Volume or other discounts
 - Selling approaches to specific customers/countries
- Manufacturing
 - Type of enrichment technology
 - Costs of production
 - Present capacity and capacity utilization
 - Capacity expansion plans

- Research and development
 - Types of technologies being developed and current status of R&D
 - Annual R&D budget
 - Quality of research and development
 - Personnel and effort devoted to R&D
- Finance and control
 - Source of funding
 - Accountability to sponsor countries.

In addition to documenting the policies and procedures in these functional areas, OURE should document how each competitor is organized and managed, and the relationship of the competitor organizations to broader organizations within the countries (e.g., similar to OURE relationship within DOE). In addition, it would be useful to identify how and by whom important decisions (e.g., technology deployment, market development) are made within competitor organizations.

Identification of
Each Competitor's
Strengths and Weaknesses

The purpose of this component of the analysis is to identify the relative strengths and weaknesses of each competitor, including the United States, in the major functional areas discussed above. Important representative areas of competitor strengths and weaknesses are listed below:

- Product
 - Quality of enriched uranium from the user's point of view, in each market segment
 - Reliability of enriched uranium delivery, short term and long term

- Marketing and selling
 - Relative strength/bargaining power with customers
 - Skills and relative strengths of sales force
 - Skills in market research
 - Relative flexibility and favorability of price and other contract terms
- Manufacturing
 - Manufacturing cost position
 - Economies of scale
 - Technological sophistication of facilities and equipment
 - Skills in capacity planning and implementation
- Research and engineering
 - In-house capability in R&D
 - Quality of R&D staff
 - Relative R&D investment
- Financial strength
 - Financial flexibility of competitor organization
 - Freedom from short-term budgetary constraints
 - Capital investment constraints, near-term and long-term
- Organization
 - Organizational responsiveness to the technology and market needs
 - Number of personnel assigned to various functions
- General managerial ability
 - Technical and managerial competence of senior executives
 - Depth of management.

In the areas of marketing and selling, this analysis of competitive strengths and weaknesses should be done on a country-by-country basis.

COMPETITOR INTELLIGENCE SYSTEM

The competitive analysis discussed above requires large quantities of data and information. OURE should therefore consider establishing a competitor intelligence system to insure that the right data is collected and that timely information on competitors is readily available. The competitor intelligence system will be supported by field data and published data. These two types of information and the staffing implications of executing a competitor intelligence system are briefly discussed below.

Field Data System

The relative lack of published information on the enrichment industry means that in general, field data sources will be a key input to the competitor analysis. Although it may be possible to obtain information directly from OURE competitors (e.g., through consultant interviews or discussions at international nuclear industry meetings), it is likely that most field data on competitors will come from OURE's customers or potential customers. These customers may have been approached by competitors, and substantial competitor information can be obtained through routine marketing contacts. To insure getting maximum benefit from this source, a data sheet or interview guide should be prepared instructing all sales staff on the types of competitor information to obtain from customers. For example, one area of direct interest relates to competitor pricing and the terms of competitor contracts. It appears that OURE has already been able to obtain this type of information from at least some of its customers, and they should systematically be doing this for all customers. Customers are likely to know a great deal about OURE's competitors, and it is worth careful preparation to attempt to learn something from them.

Another source of field data is the various suppliers to OURE's competitors (e.g., equipment manufacturers,

electric utilities). These suppliers are likely to be aware of the competitor's production levels and plans, new technologies and the like. Carefully constructed questions could prove productive in this area.

Published Data Systems

OURE should identify the important trade journals, periodicals, and newspapers in key customer or competitor countries for ongoing review. One possible source of published data that should be explored is records of committee hearings, legislative deliberations, agency reports, and the like, that may be available in competitor countries. The competitor organizations are probably required to prepare reports of operations and performance for review by the sponsor governments on a periodic basis. These reports or abstracts, or reports from the sponsor governments could provide useful information on the competition.

Staffing Implications

To effectively implement the competitor intelligence system, OURE needs to assign staff both at headquarters (to oversee the system, to compile and organize all data) and in the field (to gather the field data from customers and competitor suppliers). While consultants and others outside OURE may contribute to field data collection, OURE marketing and sales personnel will play a key role in this area. This important job is further evidence of the need for an expanded marketing staff.

Appendix E

REVIEW OF THE PROCEDURE FOR ESTABLISHING THE PRICE FOR SEPARATIVE WORK

The pricing of separative work is an important aspect of the management of OURE. The legislation that has been enacted to date on pricing of enrichment services requires DOE to charge just enough for these services "to recover the Government's costs over a reasonable period of time." In keeping with the requirements of the law, DOE has established the criteria that have been approved by the U.S. Congress and are used every year to arrive at the price for enrichment services.

Through the uranium enrichment services criteria, DOE has identified the cost components that are included in the price. Broadly stated, these are capital costs, operating costs, process development costs, administrative costs, and imputed interest on the government's investment in OURE. Some of these costs are not recovered in the year in which they are incurred but are spread out over a period of time. For instance, capital costs are recovered over a period of 25 years through depreciation charges using the straight line method. During periods of high inflation, such costs may not be entirely recovered in real (i.e., constant) dollar terms. In other words, the depreciation charges will not be sufficient to pay for the replacement of capital equipment. However, to cover any losses, adjustments are made at the end of each year to increase the price and, therefore, raise revenues in the next year.

Because the legislation, the Atomic Energy Act of 1954, as amended, is not very specific as to how DOE should establish the price every year for enrichment services, DOE has always had some flexibility in setting the criteria as well as selecting the exact procedure for determining the price of separative work. However, a private business would have more flexibility and would

probably use different pricing and accounting procedures. Certain assumptions or conventions used in the price determination procedure can have a measurable impact on the price. For instance, an accelerated depreciation method would result in earlier recovery of capital costs and, hence, higher near-term prices and lower long-term prices. The fact that the price of separative work is dependent on such aspects of the price determination procedure has raised the question as to how sensitive the price is to the various assumptions or conventions used in the procedure.

In this appendix, we shall first briefly describe the procedure by which DOE sets prices every year for separative work, describe factors that affect price, and, finally, describe cost recovery for enrichment services.

The Procedure for Determining the Price for Separative Work

Given the legislative requirement of "recovering costs over a reasonable period of time," DOE follows a procedure for determining SWU price in which it estimates future annual enrichment costs and SWU sales, and then computes a SWU price so that over a 10-year period the expected net cumulative profit is zero. The computational task is handled through the use of a recently developed computer program. The accounting principles used in the computer model are the same as those used by DOE in developing its annual financial accounts for OURE. This means that if SWU prices are kept the same in real terms for each of the 10 years and if costs and sales do turn out to be those expected, then the net cumulative profit of OURE over this 10-year period would be zero.

Besides estimates of future costs and unit sales, there is an additional input to the price computation procedure that links financial statements of one year to the SWU price for the year after. This is the cumulative profit of OURE up to the year before the one for which the price is being determined. This cumulative profit (loss) is taken as a credit (debit) when computing the following year's price. For example, when determining 1981 SWU price, the cumulative profit (loss) through the year 1980 is taken as a credit (debit).

After determining the SWU price for the first year, the computer model developed by DOE repeats the procedure for several subsequent years into the future and thus arrives at a time series of expected SWU prices based on current projections of costs and SWU sales. The pricing calculation is illustrated in Exhibit E.1. Exhibit E.2 is the most recent estimate of SWU price (in constant 1981 dollars) for the next 20 years, as computed by OURE.*

What Are The Important
Factors To Which The
SWU Price Is Sensitive

We examined the sensitivity of SWU price to changes in several variables used in the pricing calculation: depreciation period, imputed interest rate, and cost-recovery period. We found that the price is relatively sensitive to depreciation period and imputed interest rate. Price is not particularly sensitive to cost-recovery period.

The use of accelerated depreciation could cause a substantial increase in SWU price as shown in Exhibit E.3. In this exhibit, Case 1 represents the base case with depreciation of capital expenses on a straight line basis over 25 years. Case 2 represents the accelerated depreciation case with straight line depreciation over 10 years. Accelerated depreciation results in a higher short-term SWU price with the difference narrowing in future years. One would expect the curves to cross at some year beyond 2000.

The SWU price is also relatively sensitive to the rate of imputed interest. Our rough calculations have shown that raising imputed interest from 9 to 10 percent would result in an increase of about 3 percent in SWU prices.

* It should be noted that DOE includes imputed interest at 9 percent in the estimate of costs, while computing other costs in real terms. It could be argued that the real interest rate is considerably less than 9 percent. The SWU price schedule, in real terms, would thus be lower than that shown in Exhibit E.2.

Exhibit E.1

The Relationship Between Pricing and Financial Accounting

Exhibit E.2
AFC Price
(in 1981 dollars)

SOURCE: Office of Uranium Resources and Enrichment, DOE

Exhibit E.3
AFC Price Comparison
(1981 dollars)

SOURCE: Resource Planning Associates, Inc.

One factor originally thought to be important was the cost-recovery period. As shown in Exhibit E.4, the 1981 SWU price is not sensitive to the cost-recovery period if the latter is more than 3 years. A cost-recovery period greater than 3 years is needed, however, to provide some stability in pricing. For the purpose of pricing, therefore, the choice of cost-recovery period, provided it is greater than 3 years, is not an important factor.

Other factors that could be important, but whose importance we were unable to determine, include inventory accounting policy and capitalization/expensing of interest during construction and process development costs. In general, the "average cost" method of inventory accounting (OURE's current method) results in lower overall SWU prices than those computed by using the "last-in/first-out" (LIFO) method and higher than those computed by the "first-in/first-out" (FIFO) method. Also, expensing of interest during construction and process development costs (OURE's current method) results, in general, in higher overall SWU prices than those computed with capitalization of these items.

Is DOE Recovering Its Enrichment Services Costs?

Based on the financial accounts of OURE, it appears that DOE is in fact recovering all its costs. For the period July 1, 1970 to September 30, 1979, DOE reported cumulative sales of \$5.3 billion and net cumulative income of \$70 million or 1.3 percent of sales for OURE (see Exhibit E.5). However, certain inventory accounting policies, such as FIFO and averaging of inventory production costs, tend to shift the recovery of costs to future years and hence may not result in the recovery of all production costs in real terms during periods of inflation.

To test whether DOE was recovering enrichment costs on an inflation-adjusted basis, we performed a cash flow analysis for the period July 1, 1970 to September 30, 1979.

In this analysis, we computed the total real cash flow to the government for the 9-year period 1971-1979. In computing the cash flow, we did not include imputed

Exhibit E.4
Price Schedule for Various Cost Recovery Periods

Exhibit E.5
Cumulative Profit of UESA

Period Ending	Average Price (\$/SWU)	Sales (million \$)	Income (million \$)	Income as Percentage of Sales
June 30, 1971	26.71	236	(18.65)	(7.9)
June 30, 1972	30.49	165	(7.41)	(4.5)
June 30, 1973	32.53	266	4.84	1.8
June 30, 1974	36.91	460	50.59	11.0
June 30, 1975	46.36	324	10.95	3.4
September 30, 1976	60.30	612	64.66	10.6
September 30, 1977	68.23	718	93.64	13.0
September 30, 1978	84.30	1,046	(162.49)	(15.5)
September 30, 1979	96.80	1,432	34.08	2.4
Cumulative		5,259	70.21	1.3

NOTE: Parentheses indicate negative figures or losses.

SOURCE: UESA Financial Statements; DOE.

interest or depreciation charges since these are not cash expenses. We did take into account the book value of the assets at the beginning of the period and at the end of the period.

The cash flow analysis (see Exhibit E.6) shows that the total real cash flow to the government in 1970 dollars from OURE during the 9-year period was -\$1.02 billion. However, during this time, the book value of the assets increased by \$846 million, so that net real cash flow to the government was -\$173 million. Strictly speaking, however, the increase in the value of the assets should be measured in terms of the increase in its market value. But we were unable to obtain information to estimate the market value of assets. Nevertheless, the increase in the market value of the assets only needed to have been 20 percent more (in real terms) than the increase in book value in order for the net real cash flow to the government to be positive. Although our analysis is still tentative, it is reasonable to assume that the market value of DOE's assets has increased by much more than 20 percent; and, therefore, DOE is in fact recovering its costs.*

* A major asset is DOE's 30 million SWU inventory with a market value of \$2.9 billion in 1979 (or \$1.6 billion in 1970 dollars).

Exhibit E.6
OURE Cash Flows
(millions in 1970 dollars)

	1971	1972	1973	1974	1975	1976	1977	1978	1979
Sources of cash									
Gross revenue (including imputed revenues)	236.0	165.2	266.1	553.7	375.7	684.3	789.7	1,045.8	1,431.9
Net advanced payments				181.4	210.2	223.4	(26.8)	(26.0)	(76.8)
Total	236	165.2	266.1	735.1	585.9	907.7	762.9	1,019.8	1,355.1
Uses of cash									
Production of separative work	148.2	192.9	230.7	338.3	415.8	742.9	681.0	641.2	775.0
Feed purchased from tails recycle						45.4	41.1	12.7	
Operating expenses requiring cash				21.3	61.1	101.5	96.1	142.1	149.6
Acquisition of plant and equipment	6.5	16.2	41.2	77.4	152.6	286.4	347.5	371.4	398.8
Increase in working capital	23.7	11.2	10.4	80.8	39.1	174.1	396.1	191.6	264.0
Total	178.4	220.3	282.3	517.8	668.6	1,350.3	1,561.8	1,359.5	1,587.4
Net cash flow to government	57.6	(55.1)	16.2	217.7	(82.7)	(442.6)	(798.9)	(339.7)	(232.3)
GNP deflation (1970 = 100)	105.01	109.45	115.8	126.99	139.20	146.38	155.12	166.45	181.12
Real cash flow to government (1970 \$)	54.8	(50.3)	14.0	171.1	(59.4)	(302.4)	(515.0)	(204.1)	(128.3)
Total real cash flow									
	(1,019.6)								
Assets on July 1, 1970	1,508.0								
Feed material transferred to UESA									
on October 1, 1978	1,093.8								
Assets on September 30, 1979	3,448.1								
Increase in asset value	846.3								
Net real cash flow	(173.3)								