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Before the
Committee on Science and Technology
Subcommittee on Energy Research and Production
United States House of Representatives

July 28, 1983

Madam Chairman, I am pleased to appear before your Committee to discuss federal investment options for supplying enriched uranium. The issue before the Congress is whether to continue using the existing enrichment technology or to finance new processes and if the latter, which new technology might prove to be the more cost-effective investment.

My remarks this morning will touch on three points:

- The status of U.S. enrichment services in the context of the world market;
- Options to lower the costs of the United States' enrichment services and the economic consequences of these options; and
- The major uncertainties that surround the analysis.

My remarks are drawn from material in a detailed study CBO is now preparing for your Committee.

The CBO's economic analysis indicates that advanced new processes could significantly lower both the cost of providing enrichment services and the price that customers pay for nuclear fuel. Of the candidate technologies that CBO has examined, the Advanced Gas Centrifuge process, termed AGC, appears to be the least expensive from the viewpoints of both the government and the utility consumer. But compared to the total cost of the enrichment enterprise over a 43-year operating period--the span of CBO's analysis--the differences among the leading technologies appear small.

These findings must be viewed in light of two uncertainties, however. First, technical difficulties can arise in development of any new process, and the effects of these difficulties, cannot be anticipated in economic analysis. Second, the world market for this product has become highly competitive since the United States began to sell enriched uranium more than a decade ago, at times influenced by factors quite separate from price. Thus, the United States' ability to supply enrichment at low cost cannot guarantee that a customer will be found for the product.

U.S. URANIUM ENRICHMENT SERVICES IN A WORLD MARKET

Electric utilities needing enriched uranium to fuel nuclear reactors provide the Department of Energy (DOE) with uranium feed and receive the enriched product in return. The amount of work required to enrich natural uranium sufficiently for use as reactor fuel is defined as the Separative Work Unit, or SWU. A reactor requires roughly 80,000 to 120,000 SWUs a year under the typical U.S. enrichment specifications. By law, the U.S. enrichment enterprise must recover its full investment and operating costs. This leads to a charge of about $140 per SWU, roughly 4 percent of the average delivered cost of nuclear-generated electricity. Enriched uranium fuels roughly 144 gigawatts (or 144 million kilowatts) of installed nuclear capacity in the free world, of which about two-fifths is in the United States and three-fifths is overseas.

The U.S. position as an international supplier of enriched uranium has diminished markedly. Between 1969 and 1979, the United States was the dominant free-world supplier of enrichment services, but it now supplies less than 35 percent of the market outside the United States. Three related factors that have influenced this drop are price, overcapacity, and a desire for energy independence by foreign producers.

Price. Some foreign producers charge as little as $100 per SWU--$40 less than the U.S. rate. To some extent, the strength of the U.S. dollar against foreign currencies and other nations' public support for their enrichment plants account for this disparity. This price difference has motivated concern that the United States invest in technologically advanced facilities capable of producing SWUs at significantly lower costs.

Overcapacity. Global overcapacity in SWU production is a second reality influencing the world market. A large global SWU inventory is building--estimated at roughly 60 million SWUs, or a three-year world supply at the current rate of consumption. World enrichment capacity today is about 42 million SWUs and may expand. Of this, foreign enrichment plants can supply almost 15 million SWUs a year, including Soviet exports of roughly 3 million SWUs a year. The United States is now capable of supplying about 27.3 million SWUs a year. Net U.S. capacity is not expected to increase through the end of the century, but by the late 1990s, annual foreign capacity may rise by about 6 million SWUs, leading to a global total capacity of about 48 million SWUs by that year.

Because actual growth in nuclear generation has fallen far short of earlier expectations, world demand is unlikely to exhaust this production capacity before the end of the century. Actual yearly world demand for enrichment is about 20 million SWUs. Annual production, however, is probably around 25 million SWUs, because contract provisions require many customers to take SWUs for which they have no current need. World demand is not likely to press even current capacity limits until late in the century, reaching roughly 51 million SWUs a year by the year 2000. Thus, the large inventory of enriched uranium is likely to remain a major market force, depressing world prices and fostering strong competition for sales.

Non-price considerations. Many nations entered the enrichment market to gain greater control over their energy supplies and to promote domestic industries. Already committed to the large fixed costs inherent in uranium enrichment, foreign producers may be reluctant to lose sales even to lower-priced U.S. enrichment.

Taken together, excess production capacity, a large inventory of already-enriched uranium, and the national interests of foreign suppliers introduce considerable uncertainty into the outcome of any investment program. Foreign producers might themselves invest in low-cost enrichment technology, or alternatively, simply cut their price to the level necessary to maintain market share. Thus, a clear potential exists for a decline in SWU price, perhaps even to levels that would not support full cost recovery of SWUs produced by any process, existing or new.

URANIUM ENRICHMENT OPTIONS

The United States is now using the gaseous diffusion technology in plants originally built in the late 1940s and early 1950s. It is also building the gas centrifuge enrichment plant (GCEP), and it is developing both the advanced gas centrifuge (AGC) and atomic vapor laser isotope separation (AVLIS). The CBO study has examined several investment options using these technologies. Here I will discuss three from the perspective of a complete system designed to deliver enriched uranium from now until 2025. This projection period captures the full life of each new process, as well as the costs needed to operate current gaseous diffusion plants.

Option 1 would involve completion of an eight-building GCEP complex using only the proven GCEP technology (Set III and Set IV) and not the advanced materials (Set V). Production from the GCEP plants would begin in 1988, gradually reaching a maximum annual capacity of 13.2 million SWUs by 1997. One gaseous diffusion plant would be shut down, and the remaining two would provide another 13.3 million SWUs a year, for a total capacity of 26.5 million SWUs per year by 1997. Because this option would not include technologies still in the development stages--advanced AGC and AVLIS--it is conservative in its underlying assumptions about the processes that could be available for commercial deployment. Production from gaseous diffusion would also play a large part in the Option 1 enrichment system. For these reasons, the cost estimates for this option are relatively firm.

Option 2 would represent a commitment to the AVLIS process in place of GCEP. The option assumes that three AVLIS plants would be built, producing a total of 26.5 million SWUs annually. Production from the first plant would start in 1994. The existing gaseous diffusion plants would provide all SWU requirements until then, and the GCEP project would be halted at the end of fiscal year 1983, involving a one-time-only expense for decommissioning the project. The three gaseous diffusion plants would stop commercial production in 1999.

Option 3 would represent a commitment to building AGC, using Set V technology. Further development of the AVLIS process would cease. As in Option 1, an eight-building GCEP complex would be built. Centrifuge machines using the earlier Set III technology would be installed in the first two buildings, and a somewhat improved version of the Set IV machines in buildings three through six. The advanced machines (Set V) would be installed in the last two buildings, and in the 1990s, they would replace the earlier machines in buildings one through six. Production from the AGC complex would reach a maximum annual capacity of 26.5 million SWUs by 1999, at which time production from the gaseous diffusion plants would end.

Results of the Analysis

The purpose of the study is simply to determine the most cost-effective mix of technologies for supplying uranium enrichment. Because enrichment is a government-operated program, CBO reports the discounted present value of the federal outlays needed to operate each system at its assigned production level through 2025. The study also reports average lifetime enrichment costs in terms of discounted 1983 dollars per SWU, because the cost of production is important to the utility customer.

The analytical results, shown in Table 1, point out that Options 2 and 3, using the AVLIS and AGC technologies, would be much less expensive than Option 1, using only the proven GCEP and gaseous diffusion technologies. The analysis also suggests that the most cost-effective option would involve development and completion of the AGC. However, the difference in costs between the two advanced technology options, AVLIS and GCEP, could be rather small--$4.8 billion in the present value of government outlays over a 43-year period. Option 3, introducing AGC in the mid-1990s, would cost the government roughly $28 billion in outlays over the next 43 years, while Option 2, introducing AVLIS in 1994, would cost slightly more--$32.8 billion. This $4.8 billion difference between the two less costly alternatives, Options 2 and 3, amounts to only $115 million a year over the span of the analysis. In contrast, Option 1, which employs the proven GCEP technology, would cost roughly $41.4 billion in present value federal outlays--$13.4 billion more than the AGC option.

For comparison, the CBO study also examines a situation in which the existing gaseous diffusion plants supply all enrichment needs through the year 2025, reflecting eventual abandonment of new technology development. The outlays needed to support this program at the same production levels as the three options would be roughly $58 billion, more than twice the cost of the least-expensive (AGC) option. It should be noted, however, that from now through 1990, operation of the existing gaseous diffusion plants would cost roughly $15 billion in outlays, while the AGC option would require about $18 billion, and the AVLIS option, about $15 billion. The AVLIS option would have short-term costs similar to gaseous diffusion because large-scale construction would not begin until 1990.

Assumptions

In the assumptions (shown in Table 2) used to derive these results, all cost estimates are based on current DOE data. The options all presume a conscious attempt to retain the current U.S. share of world markets. Hence they are designed to supply 26.5 million SWUs a year with all new technologies operating at full capacity. (This is the production level used in DOE's recent medium-range demand forecast in the operating plan of January 1983.) The financial assumptions are a 4 percent real discount rate applied to all future cost streams to bring these costs back to their present values, and a 4 percent real interest rate is applied to all capital costs, amortized over 25 years. Finally, power costs are assumed to rise at a real rate of 0.5 percent a year.

Included in the enrichment production charges are interest, depreciation, closing the gaseous diffusion plants as necessary, and penalties associated with using less power than called for under current electricity contracts. Thus, these charges are set at levels that allow full cost recovery for each option, measured over the system's lifetime through 2025. (These costs probably will not represent DOE's actual SWU prices, since DOE sets average prices over 10-year periods, and the CBO study uses lifetime costs.)

Effect of Changes in the Basic Assumptions

Because the analysis concerns some unproven systems, it is important to test the sensitivity of the results against alternative financial, cost, production, and demand assumptions. These changes in assumptions, together with the results, are summarized in Table 3. Lifetime SWU enrichment charges are used as the basis of comparison, because they tend to be most sensitive to changed assumptions. In cases where identical changes are made in assumptions regarding project introduction schedules, power costs, and discount rates, the absolute cost of each option also changes, but the rankings do not: Option 1, using gaseous diffusion and GCEP, remains the most expensive, while Option 3, the AGC option, remains the cheapest.

For example, when capital cost overruns are assigned to all the new technologies, the rankings hold. But, if the capital costs for AGC (Option 3) are raised to the level shown in the third line of Table 3, while the estimates for AVLIS (Option 2) are not, then the production costs per SWU for the AVLIS option would be only $31.1, compared to $33.3 under the AGC program. Any assessment of the likelihood of such overruns, however, is beyond the scope of this analysis.

In another test, the United States is assumed to build each option to meet current production forecasts of 26.5 million SWUs a year, but actually produces only 19.6 million SWUs a year. This scenario might represent loss of a significant share of foreign markets in the late 1990s, thus eliminating the demand for production at full capacity. Again, the ranking of the results does not change: the AGC option remains the most economic, and the GCEP plan is the least so. However, the estimated production cost per SWU of the AGC option would rise by 20 percent from $26.70 to $32.10.

The rankings of the options also hold when planned U.S. enrichment capacity is scaled back to meet primarily domestic demand--19.6 million SWUs a year after the year 2000, as opposed to 26.5 million under the base case assumptions. In this situation, the most economic approach remains the AGC option, with a discounted production cost of $31.8 per SWU. Option 1, using current GCEP technology, is the most expensive, with SWU costs of $38.60, and Option 2 falls in between at roughly $34.40 per SWU.

CONCLUSIONS

The results of CBO's analysis suggest that, although the relative cost differences among the options are small, building the AGC process in full would result in the lowest costs to the government and to the consumer. The results also show that, if the AGC process did not perform as expected, the next best alternative would be to build AVLIS. The least cost-effective choice would be to build the GCEP complex at the current stage of proven technology, although even this option would prove substantially less costly in the long run than continuing to operate the existing diffusion plants.

In all cases, the results must be considered in light of two inherent uncertainties. First, technological factors beyond the scope of this analysis could significantly affect costs. Because the differences among the leading options are small when measured against total enterprise cost over the life of the enrichment plants, such changes could reverse the rankings presented here. Second, excess world enrichment capacity, the large existing inventory of SWUs, and foreign producers concerned with maintaining market share could lead to serious price-cutting over the period of the analysis. Such an environment might not support full cost recovery by any technology built here or abroad.

TABLE 1. RESULTS OF THE CBO ANALYSIS

	Option 1 GCEP	Option 2 AVLIS	Option 3 AGC
Technology Schedule	Production begins in 1988	Production begins in 1994	Production begins in mid-1990s
	Eight-building GCEP complex reaches full capacity in 1997	Reaches full production in 1998	Eight-building complex reaches full capacity in 1999
	Gaseous diffusion fulfills remaining capacity requirements through 2025	Gaseous diffusion capacity retired	Gaseous diffusion capacity retired
		(In billions of 1983 dollars)	
Total Discounted Federal Outlays, 1983-2025	41.4	32.8	28.0
		(Cost per SWU in 1983 dollars)	
Average Discounted Enrichment Cost, 1983-2025	39.4	31.1	26.7

SOURCE: Congressional Budget Office.

TABLE 2. BASE ASSUMPTIONS IN THE CBO ANALYSIS

- Current Department of Energy estimates on technology costs and schedules form the basis of the analysis.
- Enrichment options are designed to supply roughly 26.5 million SWUs a year in the next century, fulfilling all domestic and a significant portion of foreign demand.
- A 4 percent real discount rate is used.
- For computing SWU prices, a 4 percent real interest rate amortized over 25 years is imputed on all capital costs.
- The analytical horizon used extends from the present to 2025 to capture the full economic life of each system.
- Power costs are assumed to rise at a real annual rate of 0.5 percent from the current contract level.

SOURCE: Congressional Budget Office.

TABLE 3. ENRICHMENT PRODUCTION COSTS UNDER ALTERNATIVE ASSUMPTIONS (Costs per SWU in 1983 dollars)

Assumptions	Option 1 GCEP	Option 2 AVLIS	Option 3 AGC
Base Case	39.4	31.1	26.7
Three-Year Project Delay. Production from AVLIS and AGC begins three years later than planned.	NA	34.7	29.1
Project Cost Overruns. Equipment costs increase by 100 percent for AVLIS and AGC; building costs for GCEP and AGC increase by lesser amounts.	40.0	38.0	33.1
Higher Discount Rate. A 6 percent discount is used instead of the 4 percent of the base case.	30.6	25.7	22.6
Higher Power Costs. Real power costs rise by 2 percent rather than 0.5 percent.	45.6	32.8	27.7
Low Capacity Utilization. Capacity to produce 26.5 million SWUs is built, but only 19.6 million SWUs a year are produced.	40.3	36.0	32.1
Smaller Capacity System. Capacity to produce only 19.6 million SWUs a year is built and used.	38.6	34.4	31.8

SOURCE: Congressional Budget Office.