Radical Surgery in Uranium Enrichment

The Department of Energy is writing off a $3-billion investment, mothballing a plant, and focusing R&D on a laser technology

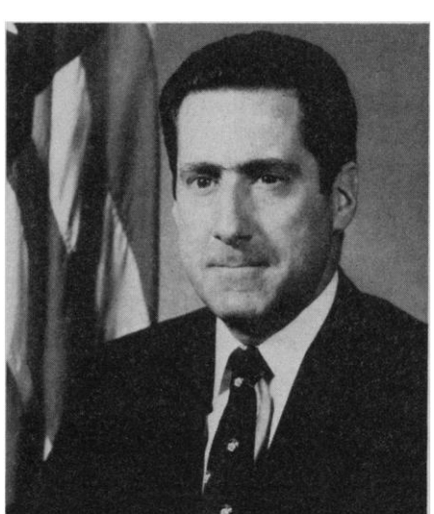
In a bold attempt to pull its $2-billion-a-year uranium enrichment business back from the brink of financial disaster, the Department of Energy (DOE) has decided to scrap a major facility in Portsmouth, Ohio, in which it has invested close to $3 billion. In addition, the department intends to mothball an existing enrichment plant in Oak Ridge, Tennessee, and perform some radical surgery on its R&D program.

These moves were prompted by what Energy Secretary John Herrington calls "the current crisis in the U.S. uranium enrichment enterprise." DOE, which is the sole supplier of enriched uranium in the United States, has seen its share of the world enrichment business plummet from 100 percent to 50 percent over the past decade. European producers are now substantially undercutting DOE's prices, and there is currently a huge glut of enriched uranium on the world market.

In the midst of this slump, DOE has been spending billions of dollars to add new enrichment capacity which is now no longer needed. As a result, its enrichment business was about to go heavily into the red, and it was in danger of losing more and more of its customers. Surveying the disaster last year, Shelby Brewer, then-head of DOE's nuclear programs, declared it "a problem as big and as bad as Chrysler." DOE officials are hoping that the analogy does not end there; the radical moves announced last week are aimed at emulating Chrysler's recent turnaround.

The root of the enrichment program's crisis is a series of decisions made a decade ago that seemed logical at the time but with hindsight have proved disastrous. In the early 1970's, when orders for nuclear power plants were booming, it was estimated that demand for enriched uranium fuel would exceed supplies within a decade or so.* DOE therefore closed its order books. European plants, which came on line in the late 1970's, consequently had an open market.

DOE also launched a $1.5-billion effort to upgrade and expand its three gaseous diffusion plants, aging behemoths that were built in the postwar years originally to produce highly enriched uranium for nuclear weapons. Then, in 1976, Congress gave the go-ahead for a fourth gaseous diffusion plant to be constructed at Portsmouth, Ohio. A year later, the design for the Portsmouth plant was changed. Instead of using gaseous diffusion, in which uranium hexafluoride gas is forced through a series of porous barriers, the new plant would use centrifuges to separate uranium isotopes. The switch in design was made because the centrifuge technology is much less voracious in its consumption of electricity than gaseous diffusion.



John Herrington

DOE has written off a project the scale of the Superconducting Super Collider.

The new plant, known as the Gas Centrifuge Enrichment Plant, or GCEP (pronounced gee-sep) was designed to have eight modules, each of which would house thousands of centrifuge machines. Cost estimates for the entire facility were put at $9 billion in 1983.

Shortly after GCEP got the green light, the bottom fell out of the nuclear fuel business as utilities began to cancel orders for nuclear plants. With European suppliers in production and the Soviet Union selling enriched uranium to some customers in the West, the expected shortages of fuel never materialized. Instead, by the early 1980's, the market was awash with material as many utilities that had ordered enriched uranium under take-or-pay contracts found themselves with more than they required. They began to sell their surplus fuel to other utilities at cut rates on a so-called "secondary" market.

By 1982, it had become obvious that the original justification for building GCEP had disappeared. Studies by the General Accounting Office and the Library of Congress pointed out that projected demand for enriched uranium had fallen so dramatically that DOE's three existing gaseous diffusion plants would provide sufficient production capacity at least until the end of the century. DOE changed the justification, however.

Because GCEP would use only a fraction of the electricity of a gaseous diffusion plant, it would be needed to provide some insulation from steeply rising electricity costs, DOE argued. However, the anticipated rise in electricity prices has not materialized. DOE now acknowledges that its power costs have in fact declined over the past 3 years, a factor that DOE admits "significantly altered assumptions regarding the economic competitiveness of the GCEP project."

The massive construction and development costs of GCEP have helped to drive up the price of DOE's enriched uranium over the past few years. The department is required by law to charge enough for enrichment services at least to meet the program's costs each year—in effect the program cannot borrow money to finance capital projects because all construction costs, together with R&D, must be covered by revenues. By October, $2.6 billion will have been spent on GCEP—an amount almost equivalent to the costs of the proposed Superconducting Super Collider.

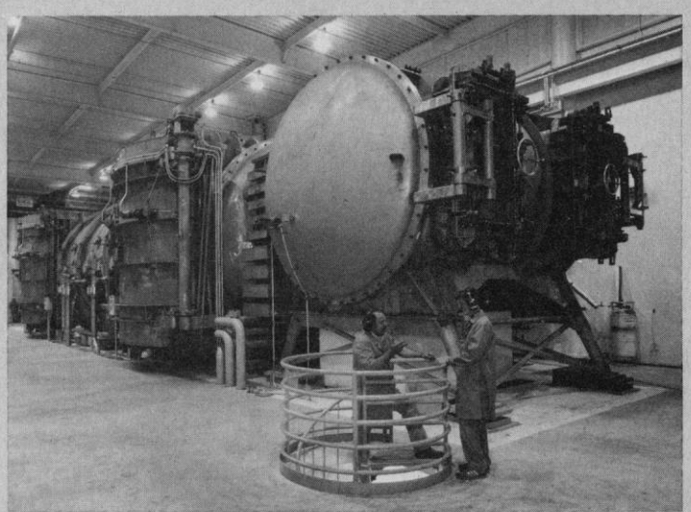
But there have been other factors at work as well. In the 1970's, DOE got itself locked into long-term contracts with the Tennessee Valley Authority (TVA) to supply electricity for the diffusion plants. The contracts require the department to pay for power whether or not it is needed, and as a result, DOE is currently paying $400 million a year for electricity it is not using—which is reflected in its enrichment prices.

*About 0.7 percent of natural uranium is the fissile isotope uranium-235. The rest is uranium-238. For use in a light water reactor, the uranium-235 content must be increased ("enriched") to about 3 percent. Weapons-grade uranium is about 95 percent uranium-235.

AVLIS: A Clear Winner

Early last year, the Department of Energy (DOE) set in motion a competition to determine which technology would be used in the next generation of uranium enrichment plants. The winner, announced by Energy Secretary John Herrington on 5 June, is a laser process that has been under development for the past decade at the Lawrence Livermore National Laboratory. The loser is a gas centrifuge process on which DOE has already invested almost $3 billion. Although no decision has been made to build a production plant based on the laser process, DOE officials say that if the technology is developed satisfactorily, a new facility could be up and running by about 1995.

The laser process, which is known by its acronym AVLIS (for atomic vapor laser isotope separation), is radically different from other enrichment technologies, which use the difference in density between uranium-235 and uranium-238 as a means of separating the isotopes. Instead, the AVLIS process uses a bank of very finely tuned lasers to create an electrical charge on uranium-235 atoms while leaving nonfissile uranium-238 atoms unchanged.



The AVLIS separator

A $25-million machine that should provide a key test of the process.

In essence, the process consists of firing light from high-powered copper-vapor lasers into a stream of uranium atoms. The lasers are tuned so that only uranium-235 atoms absorb energy. Eventually, electrons will be stripped from some of the atoms, leaving positively charged uranium-235 ions, which are drawn to negatively charged plates. The uncharged uranium-238 atoms pass through the apparatus unaffected.

AVLIS was chosen instead of advanced gas centrifuges after an intense, year-long review of the technologies by a board appointed by DOE and chaired by Peter T. Johnson, administrator of the Bonneville Power Administration. The process offers the advantages of being far less capital-intensive and cheaper to operate. Moreover, a laser plant could be built in small increments instead of in large modules, the board concluded.

A choice between the two technologies was originally scheduled for around 1988, when both would have been developed to the point of commercial demonstration. DOE decided last year, however, that it could no longer afford to keep both development programs running, and advanced the decision by 3 years. AVLIS was therefore chosen on the basis of results of tests on individual parts of the entire process, and the board noted in its report that "full-scale integrated demonstration would be required prior to a deployment decision." By deciding to pursue no further development of advanced gas centrifuges, DOE has no backup available if the laser process does not live up to expectation.—**C.N.**

Finally, DOE has also been operating an expensive R&D program in which it has been developing two competing technologies for the next generation of enrichment facilities. The first is an advanced centrifuge intended for eventual deployment in GCEP. (A less efficient current-generation model is being installed at present.) The second is an entirely different process that uses lasers to separate uranium isotopes. The development costs of these technologies, each of which amounts to about $100 million a year, were also helping drive up prices.

By late 1983, it was clear that something had to give. If DOE continued to build GCEP as originally planned and develop both new technologies, the costs of the enrichment program would exceed revenues by about $1 billion a year by 1985—or, alternatively, the price would go through the roof. The department therefore set in motion an intense reevaluation of the program that culminated in last week's radical surgery.

First, DOE offered its customers new long-term contracts that would permit them to purchase a specified fraction of their uranium needs from the secondary market. The idea was both to dry up the secondary market as quickly as possible and to get an accurate projection of demand. Second, the department announced that it would make no commitment to continue constructing GCEP beyond the first two modules. And finally, DOE said it would conduct a thorough review of the advanced centrifuge and laser programs and discontinue the one that seems less promising.

The decisions announced by Herrington on 5 June went well beyond what many were expecting. DOE's new projections indicate that demand could be met at least through the year 2000 with only two of the three existing diffusion plants. Herrington therefore announced that the Oak Ridge plant, which is the oldest and most expensive to operate, will be taken out of production and placed on "standby." This will save $50 million a year.

Because DOE does not need to add new capacity to meet demand, continued construction of GCEP could only be justified if the plant would provide significant cost savings compared with the gaseous diffusion plants. This would not be the case with current-generation centrifuges, and DOE found that even with advanced centrifuges, the cost advantage would be minimal. Moreover, completing four modules of GCEP with advanced centrifuges would cost between $3.7 and $5 billion, DOE estimates—a sum that could not be paid from expect-

ed revenues over the next few years.

In contrast, DOE has concluded that the laser separation process, which is being developed at the Lawrence Livermore National Laboratory (see box), offers potentially significant cost advantages. In addition, a laser plant equivalent to GCEP could be built for $3 billion, a sum that would not put the enrichment enterprise in the red.

Consequently, according to John Longenecker, the head of DOE's enrichment program, the laser process emerged "a clear winner." DOE has therefore bitten the bullet and announced that it is getting out of the centrifuge effort all together. The GCEP program will be terminated and all R&D on advanced centrifuges will also be stopped. By the time all the close-out charges have been paid, close to $3 billion will have been spent.

Development of the laser program will continue at the level of $80 million to $100 million a year, according to Longenecker, and DOE should be in a position by the end of the decade to decide whether a production plant should actually be built.

This strategy entails some risk because a full-scale demonstration of the laser process has not yet taken place. But DOE figures that if unforeseen problems arise with the process, it has the option of taking the Oak Ridge plant out of mothballs to meet demand beyond 2000.

DOE's decisions have been greeted with dismay in Oak Ridge and Portsmouth because they will have an enormous economic impact on the surrounding communities. They have also been sharply criticized by some members of the subcommittee on energy research and production of the House Science and Technology Committee. The subcommittee is chaired by Representative Marilyn Lloyd (D–Tenn.) who represents Oak Ridge. According to a staff member of the committee, Lloyd was given a verbal commitment from former Energy Secretary Donald Hodel to maintain some research on the losing technology but Herrington has reneged.

In general, however, DOE's decision has been applauded. Says one long-time congressional observer of the program, "They finally did the calculations using real numbers."—**COLIN NORMAN**

NRC Finds Few Risks for Atomic Vets

A new study by the National Research Council has concluded that military personnel exposed to fallout from nuclear weapons tests in the 1950's generally have not suffered an unusual number of deaths from cancer or other diseases. It did, however, find that servicemen exposed to a test in 1957 have suffered from excess leukemia, and those exposed to a series of tests in 1956 have suffered from excess prostate cancer.

The study is expected to arouse some controversy on Capitol Hill, where veterans who were exposed to the blasts have been agitating for financial compensation from the government. Overall, 222,000 veterans participated in the open-air nuclear testing program between 1946 and 1962, so the stakes are fairly large. Public concern has been stirred by a series of congressional hearings, which documented lax radiation protection during the tests, and by a popular book, *Countdown Zero*, by two veterans, Thomas Saffer and Orville Kelly.*

The purpose of the study was to test the conclusions of a widely publicized report by epidemiologist Glyn Caldwell, who found in 1979 that an extraordinarily high number of leukemias had developed among soldiers exposed to a blast called Smoky. Mortality data were gathered for most—but not all—soldiers exposed to a portion of the atomic tests between 1951 and 1957. (Not all participants could be identified, and birth dates could not be ascertained for 6 percent of those identified.) The totals were then compared with expected mortality rates in the general U.S. population and found to be equivalent or lower for participants in each series.

Coauthors Dennis Robinette, Seymour Jablon, and Thomas Preston acknowledge that in 5 percent of the cases, the cause of death could not be ascertained. But they conclude that "when data from all the tests are considered, there is no consistent or statistically significant evidence for an increase in leukemia or other malignant disease in nuclear test participants." Significantly, they say, the study replicated the earlier Smoky findings. But they also suggest that this result may be nothing more than a statistical aberration. And they dismiss the discovery of excess prostate cancer, noting that no previous tie to radiation has been established.

Gloria Christopher, executive director of the Iowa-based National Association of Atomic Veterans (NAAV), says that the study is "garbage" and "ridiculous" because it compares the test participants with a control group of civilians, not veterans. This makes it subject to bias caused by the fact that civilians are in somewhat worse health than veterans throughout their lives; as a result, the incidence of excess mortality may be underestimated.

The difficulty, says Jablon, is that an adequate control group of veterans does not now exist, and preparing one would take three more years and a million dollars. The research council is expected to propose such a project later this year. "In retrospect, it might have been a good idea for this study," Jablon told *Science*, "but we were under pressure from the [Pentagon] to get the study out quickly." He estimates that in any event, it would not have altered the results by more than 10 percent, which is not enough to affect the conclusions.

Several independent experts, including Ross Prentice of the University of Washington and Michael Stoto of the Kennedy School of Government, praised the report and found its conclusions reasonable. Glyn Caldwell, who is presently assistant director of the Arizona Department of Health Services, describes it as "reasonably well done. It does have some shortcomings, but these are well identified." He adds that "there is no way to prove or disprove that the Smoky results are due to chance." Stephen Lagakos, a biostatistician at the Harvard School of Public Health, remarks that due to the study's low statistical power, the results are "not inconsistent with excess risk." And John Bailar, a statistical adviser to the *New England Journal of Medicine*, notes that the incidence of cancer might be slightly understated because the cause of death was not always ascertained, and no search was made for cancer victims who are still alive. But fundamentally, he says, "It is a very sound piece of work."—**R. JEFFREY SMITH**

* G. P. Putnam's Sons, New York, 1982.