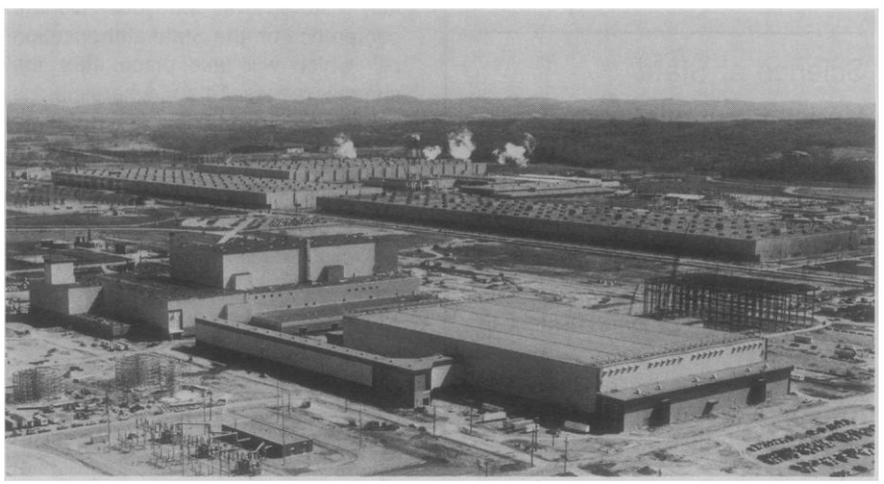
Uranium Enrichment: Heading for the Abyss

A financial and political crunch is in store as DOE tries to build a $10-billion enrichment plant amid a worldwide surplus of reactor fuel

The federal government's $2.3 billion a year business enriching uranium for nuclear power plants is heading toward a major crisis. A victim of the plummeting fortunes of the nuclear industry and some disastrous miscalculations by the Department of Energy (DOE), it is caught with billions of dollars of construction in progress just as projected demand for enriched uranium is sinking like a stone. As a result, the enrichment program will soon have a mass of red ink on its books and a big fight with Congress on its hands.

At the center of the mounting controversy is a mammoth $10-billion enrichment plant that is now rising on the industrial landscape of Portsmouth, Ohio. Known as the Gas Centrifuge Enrichment Plant, or GCEP (pronounced gee-sep), it is the biggest construction project in the nation—a behemoth that will cost more than twice as much as the Clinch River Breeder Reactor.



The Portsmouth centrifuge plant

The nation's biggest construction project—if it is all built.

The Department of Energy, which manages the enrichment program, argues that GCEP represents the best hope for getting the enrichment business onto a more stable economic footing in the 1990's. But to its critics, the plant is a boondoggle whose capacity is not needed and whose construction will drive up the price of enriched uranium in the near term. They claim that GCEP will be obsolete before it is completed, and argue that it should at least be put on hold until new technologies—based on lasers or advanced centrifuges—are available in the early 1990's.

Getting GCEP built in the face of growing opposition and dwindling demand for enriched uranium is not the only problem facing the program.

- The government's three existing enrichment plants have recently undergone a major overhaul, costing $1.5 billion, to increase their capacity by 60 percent and improve their performance. Yet demand is so depressed that these expensively refurbished plants are now being operated at only about 35 percent capacity and one may soon have to be shut down.
- A huge "secondary market" has recently emerged as utilities, saddled with surplus uranium they ordered several years ago under fixed contracts, are unloading the material to other utilities at substantial discounts. According to DOE estimates, there may be enough enriched uranium slopping around in the secondary market to meet worldwide demand for 2 or 3 years. The surplus is expected to grow in the next few years and will not be worked off until the early 1990's, which means that demand and prices will remain depressed for the foreseeable future.
- DOE is currently paying more than $100 million a year in penalties to the Tennessee Valley Authority (TVA) for electricity it had contracted to buy to operate enrichment plants but which is no longer needed. Next year, these penalties will be more than $200 million and by 1992, the accumulated payments will total a staggering $1.23 billion, according to a recent estimate by the General Accounting Office (GAO).
- Ten years ago, the United States held a worldwide monopoly on sales of enriched uranium, but its share of the non–U.S. market has now slumped to about one-third and DOE's prices are being undercut by its foreign competitors. This price differential could worsen in the next few years as DOE tries to raise revenues to pay for GCEP.

How DOE got itself into this mess is relatively straightforward: in the 1970's it grossly overestimated the demand for enriched uranium and made a number of decisions it later came to regret. At the time, the policies seemed sensible, but "with 20/20 hindsight, the decisions were wrong," says Shelby T. Brewer, head of nuclear power programs at DOE.

A decade ago, the most pressing problem facing the enrichment program was how to build capacity fast enough to keep up with soaring demand for reactor fuel. The federal government began enriching uranium for the fledgling nuclear power industry in the late 1960's, using three massive plants that were built in the 1940's and early 1950's to produce highly enriched uranium for nuclear weapons.* The Atomic Energy Commission (AEC), which built and operated the plants, essentially ran a service business, enriching uranium for both domestic and foreign utilities and charging enough to cover costs. By 1974, so many nuclear plants were under construction or on order worldwide that the AEC calculated that demand for enriched uranium would exceed capacity by the early 1980's. The AEC then made the first of several decisions that would come back to haunt the enrichment program: it announced that it would accept no more new orders. The order books remained closed until 1978.

Because the United States was then the sole commercial supplier of enriched uranium in the non-Communist world, AEC's abrupt moratorium had far-reaching repercussions. One consequence was a major boost to Europe's enrichment business. With no competition for new orders, two groups which built enrichment plants in the 1970's—Eurodif, a consortium of French, Spanish, Belgian, and Italian government and private inter-

*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.

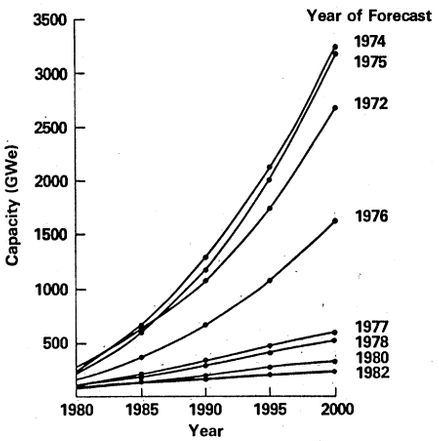
ests, and Urenco, a consortium of British, West German, and Dutch interests—picked up two-thirds of the enrichment business outside the United States by the end of the decade.

The United States, meanwhile, was scrambling to increase its own capacity. A 10-year effort to expand output from the three existing plants—located in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio—was already under way. But even with this expansion, the AEC estimated in 1975 that as many as 8 to 12 new plants would be needed by the end of the century. Congress was duly persuaded to give the go-ahead for immediate construction of one new facility.

In 1977, the Carter Administration announced that the plant, to be built alongside the existing enrichment facility at Portsmouth, would use a new technology. The three postwar plants all employ a process called gaseous diffusion in which uranium hexafluoride gas is forced through thousands of porous barriers. Because lighter molecules containing the fissile uranium-235 isotope tend to diffuse through the barriers more quickly than those containing uranium-238, the concentration of fissile material increases as the uranium hexafluoride passes through the plant. The process has a major drawback: it is a voracious consumer of electricity. Since electricity prices were going through the roof in the 1970's, the Carter Administration decided that the new Portsmouth facility would use gas centrifuges, a novel but potentially much less energy-intensive enrichment technology. In this process uranium hexafluoride is spun at high speeds in a series of massive centrifuges. The new plant—GCEP—was originally scheduled to be in full production by 1986.

While all this was going on, however, the bottom fell out of the nuclear power business as utilities, faced with escalating construction costs and declining growth in electricity consumption, canceled or deferred scores of power plants. The impact on uranium enrichment has been dramatic. Since 1975, when Congress gave the go-ahead for GCEP, the projected demand for U.S. enriched uranium in the year 2000 has dropped by more than a factor of 10 (see chart). As a result, the GAO and the Congressional Research Service both concluded last year that DOE's existing gaseous diffusion plants have more than enough capacity to meet demand until the end of the century and beyond. In other words, the original justification for building GCEP has evaporated.

U.S. Supplied Nuclear Power Growth



Enrichment's sinking fortunes

No matter; DOE now says that although GCEP may not be justified simply to meet rising demand, it is needed to stabilize the cost of enrichment and stave off foreign competition. Without it, "the United States would price itself out of the enrichment business," claims Brewer. In essence, DOE is saying that enrichment is no different from, say, steelmaking: in spite of worldwide overcapacity, the United States must build new, more efficient plants and retire its old ones if it is to stay competitive.

There is certainly good evidence that the United States is losing enrichment business and that it may lose a lot more. For one thing, thanks in part to those penalties DOE is paying TVA and to the rise of the dollar against European currencies, the substantial price advantage enjoyed by the United States in the 1970's has disappeared. It is now being undercut by Eurodif, Urenco, and the Soviet Union (which is now selling some enriched uranium on the international market). Then there is the secondary market. According to DOE estimates, some two-thirds of the material in the secondary market is of European origin and it is being offered in the United States at substantial discounts.

The first indication of a shift in the market came in August 1982, when Florida Power and Light bought some European uranium on the secondary market. Four months later, South Carolina Gas and Electric became the first U.S. utility to sign a contract directly with Eurodif rather than DOE.

It is debatable, however, whether building GCEP is the best way to shore up the U.S. enrichment business in the long term, and the plant will certainly add to the economic and political problems in the short term.

The immediate difficulty is that the construction costs of GCEP in the next few years will push outlays on the enrichment program well above revenues from sales of enriched uranium. In 1987 alone, according to DOE estimates, the program will be about $500 million in the red. This means that either Congress and the Office of Management and Budget must approve a departure from the current pay-as-you-go policy, under which DOE balances costs and revenues on an annual basis, or DOE will have to raise its prices drastically. The former would make the program highly vulnerable politically, and the latter would certainly price the United States out of the enrichment business.

As for the plant's long-term economics, they depend on whether all or only part of the plant is built, how rapidly the state of the art in centrifuge technology advances, and how much further projected demand for enriched uranium sinks.

The current plan, which is now under review within DOE, is to build GCEP in eight modules, each of which is a massive process building housing thousands of centrifuges. The first two buildings are under construction, and their centrifuges are expected to be installed and running by 1988. The other buildings would be added in stages, with final completion of the entire plant scheduled for 1994. DOE anticipates that centrifuge technology will advance as GCEP is built so that the machines installed in the final buildings will be two to three times more efficient than those in the earlier modules.

By the end of this fiscal year, DOE will have spent some $1.8 billion on GCEP and, by the time the first two process buildings are completed, it will have gone through half the projected capital cost of the entire eight-module plant. (The total plant cost is now put at some $9 billion, in 1984 dollars.) The high initial capital cost is explained in part by the fact that DOE decided to construct central facilities capable of handling the work of all eight modules. This, of course, provides a built-in incentive to finish the plant once the initial buildings are completed: later modules will be cheaper to build and, because they will employ more efficient machines, they will be far more productive.

DOE's current justification for building GCEP is that, because it will use only about 5 percent of the electricity consumed by a gaseous diffusion plant to produce a given quantity of enriched uranium, it will help reduce the long-term price of enrichment. But last year, GAO questioned that claim because, it said, DOE was still using unrealistically high estimates of demand; at lower demand levels, GCEP's cost advantage dis-

appears, GAO concluded. A report soon to be published by the Congressional Budget Office, however, will argue that GCEP will be cost effective if the advanced centrifuges now scheduled for only the final buildings were installed in the entire plant. This would mean ripping out the less efficient machines a few years after they are installed and replacing them with the advanced centrifuges.

In essence, this would require building part of the plant twice. That may reduce costs in the long term, but it would increase outlays in the short term and aggravate the political problem of getting Congress to come through with the money. It also invites the question, why install the less efficient machines at all? Why not put the whole thing on hold until the advanced machines are available? That, in fact, is precisely what Representative Richard Ottinger (D–N.Y.), a critic of GCEP, proposed last year.

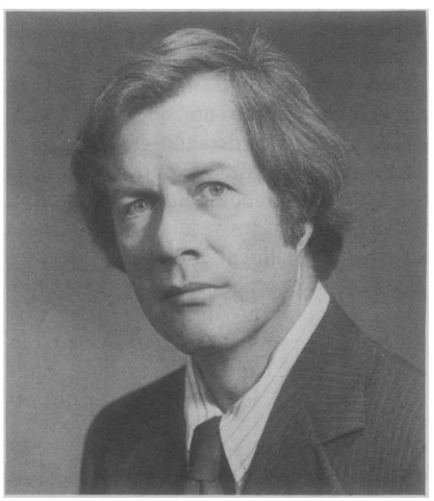
In this regard, it should be noted that centrifuge development is proceeding so rapidly that the advanced machines could be ready much earlier than originally expected. According to Richard Grant, who is heading the centrifuge program for Boeing, key elements of the machines are already under test and commercial production could come as early as 1988–1989—some 3 to 4 years ahead of schedule.

There is, however, another factor that should play a crucial role in deciding what to do with GCEP: the development of a technology based on lasers that may offer substantial cost advantages over even advanced centrifuges. DOE, urged on by Congress, is now pumping about $100 million a year into the development of laser enrichment.

The process, first developed by scientists working for the Avco Everett Research Laboratory, involves subjecting a stream of atomic uranium vapor to a series of very finely tuned laser beams. Energy is absorbed only by atoms of uranium-235, which eventually lose an electron. The resulting uranium-235 ions are then collected by passing the vapor stream through a magnetic field, which deflects the ions while the neutral uranium-238 atoms pass straight through.

Avco Everett, in partnership with an Exxon subsidiary, spent some $77 million of their own funds developing the technology during the 1970's. But in 1980 they decided that the time was not ripe to build a private enrichment plant and proposed a joint venture with DOE to commercialize the technology. In the meantime, however, the Lawrence Livermore National Laboratory was working on a parallel laser process that by the early 1980's was also ready to be scaled up. For reasons that have never been adequately explained, DOE turned down the Avco Everett/Exxon proposal and, in April last year, announced that it would build a demonstration plant based on the Livermore process. (Avco Everett disbanded its enrichment team, but has managed to salvage some of the work: it is now using the lasers in a Defense Department program to develop laser communications with submarines.)

When it selected Livermore, DOE planned to have a demonstration laser facility in operation by 1990, but it has recently brought forward the target date to 1987. (The speedup will be achieved by use of lasers being built at Livermore to separate isotopes of plutonium in a defense program.) As it happens, that is about the time when the advanced centrifuges are expected to be ready for commercial development.



Shelby Brewer

Counting on GCEP to lower prices.

This has led supporters of the laser program to argue that no firm commitment should be made to complete GCEP until both the laser process and the advanced centrifuges have been properly evaluated. DOE "should put everything [at GCEP] on hold as best they can and then compare the two processes," says James Davis, who is heading the Livermore effort. Davis has no doubts about which would win. The laser process at present promises to be much less capital-intensive than centrifuge technology, and its operating costs, although still somewhat uncertain, are expected to at least match those of advanced centrifuges.

So far, the enrichment program has attracted little interest on Capitol Hill beyond the committees that oversee DOE and appropriate the funds. GCEP, for example, has not attracted anything like the attention devoted to the much less expensive Clinch River Breeder Reactor. But that may change in the coming months as the program's problems become more widely known. Later this year, for example, Senator Gordon Humphrey (R–N.H.), a critic of GCEP, plans to hold hearings with a subcommittee he chairs that has jurisdiction over TVA, to look into the massive penalties DOE is forking over to the utility. And next year, Ottinger, who chairs a key House energy subcommittee, will get a crack at the program when it comes up for authorization.

Already, the House Committee on Science and Technology and the appropriations committees have put DOE on notice that there could be rough times ahead. They have approved funds for only the first two modules of GCEP and demanded a study of what should be done beyond that. DOE, meanwhile, has shaken up the management of the program, bringing in to head it John R. Longenecker, a 34-year-old engineer who formerly managed DOE's Clinch River program. Longenecker said in an interview that the whole program—including stopping GCEP—is under examination, and a new plan will be formulated by the end of the year.

The options facing DOE and Congress are complicated and painful. To cancel GCEP now would mean writing off the $1.8 billion already spent plus some $350 million in cancellation charges. It would also run the risk of seeing the operating costs of the gaseous diffusion plants climb steadily, with no relief if the laser process does not live up to expectations. But to continue with GCEP will require some major infusions of cash in the next few years from a Congress concerned about budget deficits and about hidden subsidies to the nuclear industry. Building GCEP now, moreover, may well preclude building a laser plant in the 1990's, even if laser technology ultimately turns out to be superior. The alternative, putting GCEP on hold to wait for advanced centrifuges or lasers, would incur considerable costs if the plant is later reactivated. Finally, if construction were halted after only two modules, the plant will be of dubious economic value because of those huge capital expenditures DOE has already sunk into central facilities for the entire eight-module operation.

One potentially attractive solution to all this is to turn the whole business over to private industry. Getting enrichment out of the federal appropriations process would mean that new construction could

be financed by borrowing on the capital markets rather than from current revenues. Decisions would also be made on a strictly business basis, and industry, which stands to benefit from lower enrichment prices, would bear the risks. The Reagan Administration, which is ideologically committed to getting the federal government out of running businesses, would very much like to turn enrichment over to the private sector, but it is not at all clear how it could be done.

One proposal, under consideration in the White House, is simply to announce that the federal government will not finance any more construction after the first two modules of GCEP. That would at least focus attention on how future capacity should be financed, but it would do little to help avert the budget crunch in the next few years. A more radical idea, put forward by the conservative Heritage Foundation, would be to turn over management of existing plants to a group consisting of utilities that currently have contracts to purchase enriched uranium from DOE. This management corporation would essentially lease the plants for a fee to pay off their depreciated value, and plan and raise capital for future plants. In any case, given the huge uncertainties facing the enrichment business, private industry is not leaping at the investment opportunity.

For DOE, the immediate problem is how to get through the next few years, especially in view of that huge secondary market depressing demand and prices. "Somehow," says Brewer, "we must get through the valley of the shadow—this secondary market problem—and emerge with the best technology." Billions of dollars are riding on how DOE chooses to do it.—**COLIN NORMAN**

Study of Atomic Veterans Fuels Controversy

Criticism of a study of U.S. soldiers in Hiroshima and Nagasaki illustrates the pitfalls of dressing up a political study as purely a scientific investigation

The National Research Council (NRC) recently fired another salvo in an ongoing battle between several veterans organizations and the scientific community over the merits of conducting an epidemiological study of U.S. soldiers who were in Japan shortly after the end of World War II. The veterans, led by a retired mail carrier from Oregon, claim that an unusual number of soldiers who passed through Hiroshima and Nagasaki have developed multiple myeloma, a bone cancer, as a result of exposure to residual radiation after the bomb blasts in 1945.

The NRC, in a controversial report released on 16 July, suggested that the veterans' claims are unwarranted and that an epidemiological study would probably be a waste of time. Specifically, it said that only nine cases of multiple myeloma had been confirmed among members of the occupation force "stationed in or near Hiroshima and Nagasaki." This, said the NRC, constitutes an incidence no greater than that in the general population.

Although the report has been welcomed by the Department of Defense, it has outraged the veterans and attracted pointed criticism from several outside scientists. The National Association of Atomic Veterans, a lobby organized to win financial compensation for veterans who blame their ailments on radiation exposure, has denounced the report as "medically criminal." Glenn Alcalay, an official of the group, says that the NRC ignored some victims of myeloma on a list of U.S. occupation force members compiled by his organization. "If the people who were ignored or are dead from the disease are counted, we're dealing here with an epidemic," he says.

Although there seems to be broad agreement that Alcalay is wrong about a cancer epidemic, several independent scientists agree with him that the NRC report has some serious shortcomings. "The NRC is probably correct in its conclusions, but I think their methodology is slovenly," says Bernard Greenberg, a biostatistician who is dean emeritus at the University of North Carolina School of Public Health. Similarly, Edward Radford, a radiation epidemiologist at the University of Pittsburgh, says "I would doubt very much if there was a significant exposure to radiation by the U.S. occupation force, but I think that the study adds nothing to a discussion of whether there really is more myeloma than one would expect." He and Greenberg agree with the veterans organizations that the NRC failed to look diligently for myeloma victims, and that it may have used an inappropriate control group to estimate whether the occupation force members suffer from excess cancers.

The response of the NRC, which is the operating arm of the National Academy of Sciences, is essentially to acknowledge the presence of shortcomings in the report and to explain that it was intended from the outset to serve a primarily political, not scientific, purpose. "We're not in a purely scientific world here," says Seymour Jablon, a radiation expert who coordinated the study as director of the NRC's Medical Follow-up Agency. "We're in a world of pressures—from the veterans on one side and of course from the government on the other." Jablon is unwilling to describe the report as sound science. "I don't think I want to answer that question," he says.

The idea for the report came from an NRC study in 1981 on the feasibility of conducting a full-scale epidemiological investigation. A panel chaired by Brian MacMahon of the Harvard School of Public Health had been formed at the request of the Pentagon for the purpose of deflecting growing congressional interest in such an investigation, Jablon says. "The Pentagon was searching for a way to resist what they saw as an unwarranted demand for an expensive undertaking. And so they turned to the NRC."

The panel listened to testimony from veterans organizations, the Defense Nuclear Agency, and the National Cancer Institute and concluded that the potential benefit of an epidemiological investigation was not worth the "formidable" cost. The panel reasoned that radiation doses received by the soldiers were simply too low to cause any detectable excess cancers, unless existing assumptions about the effect of radiation on human health are incorrect.*

In what MacMahon describes as a sop to the veterans, the NRC panel did recommend closer scrutiny of a list of alleged myeloma victims compiled by Vic-

*The other panelists were Robert Anderson of the University of New Mexico, John Auxier of Oak Ridge National Laboratory, Stuart Finch of Rutgers University, Alun Jones of Chalk River Nuclear Laboratories in Canada, and Arthur Upton of the New York University Medical Center.