Hard Times in Magnetic Fusion

Two straight years of budget cuts are forcing a reexamination of the program's goals and timetable; major machines could be mothballed

When Congress cut $31 million from the 1985 magnetic fusion energy budget last summer it sent shock waves through the fusion laboratories. After almost a decade of growing budgets for the drive to bottle the awesome power of hydrogen fusion, the program was put on a slower track. The fusion community found this hard to accept but hoped it would be temporary.

Last year's cut turned out to be only the first installment, however. Following Congress's cue, the Reagan Administration, which until now grudgingly supported modest budget hikes for magnetic fusion, wants to chop the program by another $47 million in 1986, to $390 million. And Congress, which is fighting to protect Social Security, Medicaid, and other threatened social programs, is virtually certain to support the cutback.

Not only are major experiments being stretched out, but the back-to-back budgets cuts are also triggering 343 layoffs at more than six laboratories this summer. And still more trouble may be in the offing. Already, White House and congressional aides are betting that the program will be hit with another 10 percent cut in 1987. As a result, some major facilities could be mothballed.

Says John F. Clarke, associate director for fusion research at the Department of Energy (DOE), about the impact of additional funding losses: "At this point it would be psychologically disastrous." The budget crunch is forcing DOE and fusion laboratories to rethink the program strategy and look closer at smaller, less costly reactor concepts, which until now have taken a back seat to larger experimental machines. Furthermore, the U.S. fusion community now has resigned itself to the fact that any large-scale machine must be an international undertaking.

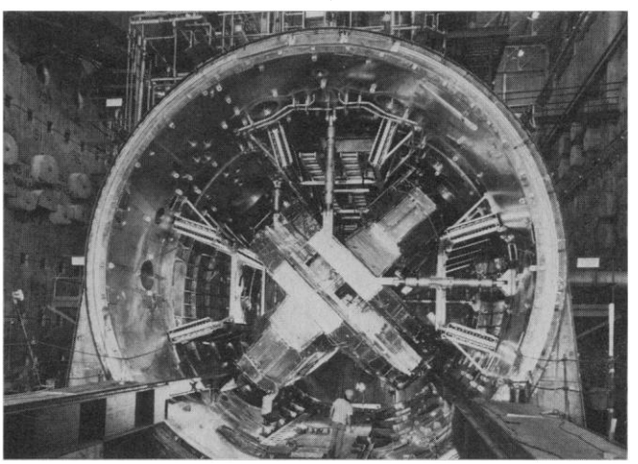
In essence, the Reagan Administration has won its 4-year battle to shift the fusion program's reactor development focus to emphasize basic science. The Magnetic Fusion Energy Engineering Act of 1980, which authorized a $20-billion drive to build a demonstration reactor by 2000, remains in force, but has been effectively shelved. "Energy no longer is an issue," observes Lee Berry, associate division director at Oak Ridge National Laboratory. "They are saying 'We don't need fusion now'."

But the Office of Science and Technology Policy also has argued for slowing down the program's pace until the physics is better understood and the technology advances. And to an extent the program's reorientation is viewed as healthy because scientists are looking more critically at the commercial viability of machine concepts. "We have not yet been successful in coming up with designs that we're proud of as commercial reactors," admits Stephen O. Dean, president of Fusion Power Associates, the industry trade organization.

However, Dean worries about the program getting bogged down in scientific exercises that Congress cannot appreciate. "We have to show that we are moving along the path to fusion power," says Dean, who fears program funding will continue to fall. Just how or when this cash hemorrhage will be stopped, no one can say. What is clear is that some important experiments, as well as the fusion community's campaign for an ignition machine are in jeopardy.

The much vaunted "break-even test" at Princeton's Plasma Physics Laboratory already has been delayed by DOE from 1986 to 1988 in the wake of this year's reduced budget. The experiment's aim is to create a fusion reaction of sufficient temperature, density, and duration to produce more energy than is required to start the fusion process. However, conducting this experiment as planned would make the $493-million Tokamak Fusion Test Reactor (TFTR) radioactive. This would reduce its availability for related plasma physics research.

Completion of the Mirror Fusion Test Facility upgrade (MFTF-B) experiment at Lawrence Livermore National Laboratory, a $364-million project, also is being delayed. The massive machine, congressional and industry sources say, could be mothballed without ever being switched on. Its fate may hinge on how the fiscal year 1987 fusion budget that DOE is preparing fares before the White House's Office of Management and Budget next fall and the Congress next winter. "Everyone's view is that [magnetic fusion] is probably facing another budget cut in '87," says James A. Maniscalco, fusion program manager at TRW, a mirror machine contractor.



Mirror reactor

Additional budget cuts in 1987 could force the Department of Energy to mothball the Mirror Fusion Test Facility upgrade without conducting any experiments. Located at Lawrence Livermore National Laboratory, the $364-million project lacks some diagnostic and heating equipment.

The budgetary pinch goes beyond delaying experiments. To date the magnetic fusion effort, program managers note, has attracted some of the best scientists in the nation. But large and small laboratories worry that the coming wave of layoffs may spur key personnel to bolt to stronger programs—the Administration's Strategic Defense Initiative, for example. Princeton is ready to cut 14 percent of its 1300 member staff in July. Likewise, Livermore is expected to lose 100 and other DOE fusion facilities at least 63 more staffers.

The upheaval in magnetic fusion is being driven by more than tight budgets. Congress, while continuing to support fusion, is increasingly skeptical of the

program. "The fusion program was intensely oversold (to Congress) and based on a lot of improper expectations," says Senator J. Bennett Johnston (D–La.), ranking minority member on the Appropriations subcommittee on energy and water development. "It was presented to Congress as if 'we are just getting ready to make this great invention'."

Other members of the House and Senate are questioning the performance and direction of the magnetic fusion program, too. "The Congress has . . . lost its patience with the fusion program," says Representative John T. Myers (R–Ind.), ranking minority member on the House Appropriations energy and water development subcommittee. "They just have not done what they said they could," complains Myers.

Ironically, it is the budget cuts imposed by Congress and the Reagan administration that are keeping fusion from meeting some of its near-term goals. Says DOE's Clarke in defense of the program's performance, "We are moving forward on scientific and technical issues. If people would only look at the program they would see we are doing what we said we would do."

However, conducting the deuterium-tritium break-even test at Princeton's TFTR in 1988 was not what was promised. It was originally scheduled for 1986 but has been put off for 2 years in part to save $30 million in remote-handling equipment costs. Instead, a deuterium demonstration test, which will approximate the conditions of a deuterium-tritium reaction without producing net energy, is now planned for 1986.

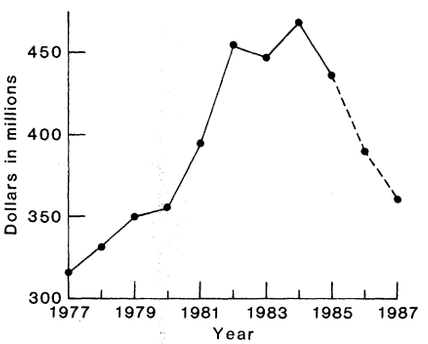
The delay in the break-even test may set the stage for a symbolic race between the U.S. TFTR and the Joint European Torus. From a science standpoint, laboratory officials note, the contest is meaningless, but how it is perceived in Congress is hard to predict. "It's going to look like we lost our lead if the Europeans use tritium shots first," says Fusion Power's Dean.

Wary that mothballing Livermore's mirror machine without ever using it might anger Congress, DOE's Clarke and T. Kenneth Fowler, Livermore's associate director, are trying to scrape together enough funds to operate the machine at least for a while. "I don't want to abandon MFTF-B," says Clarke. "What we are trying to do is capture something for our investment."

A competing concept to the doughnut-shaped tokamak, Livermore's mirror machine has had its 1986 operation date slip steadily over the years because of tight budgets. When first authorized, DOE had targeted 1986 as the date for choosing between mirrors or tokamaks as the technology for the next major machine. However, tokamaks from the outset have had the edge and that lead has grown as funding for mirror research has been deferred.

The attraction of the cylinder-shaped mirror machine is its linear geometry and potential for steady-state operation. Periodic replacement of neutron-damaged reactor walls—or blankets—also could be less complex in a mirror machine than a tokamak.

Magnetic fusion program funding



Budget for 1986 reflects White House request. Projected 1987 budget assumes 10 percent cut.

Despite its potential, no white knight is in sight. Whether the big mirror ever operates as designed depends on resolution of physics problems at Livermore's Tandem Mirror Experiment (TMX-U). The forerunner of MFTF-B, its end plugs, or thermal barriers, deteriorate when certain plasma densities are exceeded. Although Livermore's scientists are confident they can overcome this problem, it may not matter.

DOE's revised plan is to deploy MFTF-B with limited neutral beam and radio frequency heating as a short-pulsed, one-half second device. "That's the best thing that can happen," says Clarke soberly. MFTF-B was designed as a long-pulsed machine that would achieve quasi steady-state operation with 30-second bursts. But that would require $60 million in diagnostic and heating equipment. "We can't do everything," sighs Clarke. "There is not enough money."

The problems facing the program's big machines could, ironically, be a boon for alternative devices. In February, DOE adopted a revised program plan that entails a slower, decentralized approach. The plan flatly declares that new major machines, so-called "centerpiece projects," are out for the rest of the century. With no large devices the scale of TFTR or MFTF-B under construction, there could be more money available for research on alternate machine concepts such as reverse-field pinches, stellarators and compact toruses.

Joseph N. DiMarco, a fusion program leader at Los Alamos National Laboratory, thinks the new emphasis will help. DiMarco's group is presently trying to sell DOE on an upgrade of ZT-40, a 6-year-old reversed-field pinch experiment. This proposal, he says, "fits in well with the plans enunciated by Clarke."

DOE's plan focuses on four specific technical issues: identifying a suitable confinement system (tokamak and mirror designs may not prevail); developing new materials suitable for a fusion environment; design and testing of fusion components and systems, including blankets; and conducting a burning plasma experiment. These problems must be tackled in low-cost facilities, DOE says.

The new strategy means delaying or scrapping plans for a $1.5-billion Tokamak Fusion Core Experiment, a next generation burning plasma device. Instead, DOE is looking at concepts for a cheap, compact ignition device costing about $300 million. No formal machine concept is close to adoption yet, but DOE's Magnetic Fusion Advisory Committee is studying reactor options. Clarke hopes to begin design work on a small ignition device in 1988. Retirement of facilities like TFTR and/or MFTF-B, he notes, could free up the necessary funding to construct the device.

But the drive to build a cheap small machine is likely to run up against the Office of Management and Budget's ban on new starts and against tight-fisted appropriation committees. "I don't think there is an automatic spigot for this program that is going to be sending forth a stream of dollars," warns Johnston. "We are not interested in building a premature experiment just to prove you can achieve ignition."

Congressional and industry supporters of the fusion program in fact worry that money problems could create a vicious cycle for the program. If existing experiments are slowed down and new ones are deferred, the program could lose political and scientific momentum and become vulnerable to new attacks. "Any time you reduce your visibility you are in for more funding cuts," notes Allan T. Mense, senior scientist for McDonnell Douglas Astronautics Company. "I think the program is getting itself between a rock and a hard spot," says Maniscalco of TRW.

The House Science and Technology and Senate Energy subcommittees on energy research agree. The science com-

mittee proposed a $415-million budget and the Senate Energy committee is expected to take similar action. But the Appropriations committees in both houses, which hold the real power, want to slow it down. Representative Tom Bevill (D–Ala.), chairman of the House Appropriations subcommitee on energy and water, says some fusion research efforts may have to be abandoned. "The time has come to make a choice," says Bevill, who instigated Congress's cutback of the program in 1984. To overcome this opposition, fusion's supporters are going to have to lobby harder. "We don't participate very much in the national political process . . . ," complains Fusion Power's Dean. The community, he says, must "get pushy."

Indeed, fusion's political base has eroded in recent years. Past champions like the late Senator Henry M. "Scoop" Jackson (D–Wash.) and former Representative Mike McCormack (D–Wash.) are gone. A loyal and influential political base remains, but it is not strong enough to keep fusion on a fast track. Even if the fusion community can expand its lobbying effort, it will face an uphill battle. Pressure to hold down federal spending is sure to remain strong and energy supplies are expected to be plentiful for the foreseeable future.—**MARK CRAWFORD**

New French Law Boosts Industrial R&D

Paris. Increased tax incentives for companies that invest in research and development (R&D), the creation of over 1000 new jobs a year for scientists and engineers, and a scheme under which industrial scientists will be entitled to take a year's "research sabbatical" in a government laboratory, are three of the main features in a new 3-year program for science which was unveiled in Paris last week by French Prime Minister Laurent Fabius.

The government's overall aim, according to Fabius, is to increase the proportion of France's gross national product devoted to civilian research and development to 2.6 percent by 1988—compared to 2.25 percent at present—with an eventual target of reaching 2.9 percent by 1990.

The prime minister, outlining the details of a new research law that will shortly be submitted to the French Parliament, argued that the 4 percent increase in real terms in each of the next 3 years that this target will require underlines the extent to which science remains a top priority of France's socialist government.

More significant than the figures alone, however, is the shift in philosophy that lies behind the new proposals when compared to those enshrined in the earlier 3-year research law, passed in the summer of 1982.

The earlier law sought to boost French science and technology not merely by endorsing a major increase in funding for R&D—17 percent in the first year alone—but also identifying those technical areas where most of this increase was to be channeled by the government.

The French enthusiasm for "dirigisme," reinforced by a more widely held feeling in Europe that governments need to concentrate their resources on strategically important fields of research, still finds expression in the new proposals. For example, it is widely expected that the 1400 new research and engineering jobs that Fabius promised will be created in each of the next 3 years will primarily be in fields with direct or indirect relevance to some form of advanced technology.

Furthermore, the National Center for Scientific Research, France's leading agency for the support of basic research both in universities and in its own laboratories, recently has sought to curry favor with the administration by announcing a list of 20 strategic priorities—ranging from mathematics and the exploitation of remote sensing techniques to the multidisciplinary sciences of communication and evolution—for increased funding over the next 5 to 7 years.

Nevertheless, the proposals for the new law also reflect a growing awareness in Paris that an excessive desire for centralized planning and control of research programs (by no means confined to the present socialist government) is proving less productive than had been hoped.

The Minister of Research and Technology, for example, physicist Hubert Curien, admitted at a meeting of the Council of Ministers last week that government efforts to stimulate the applications of genetic engineering to agriculture and food production, had been disappointing, with both fields "paradoxically keeping their distance from recent developments in modern biology."

The proposed new research law, while maintaining the emphasis on key areas such as microelectronics and biotechnology, will introduce several measures designed to moderate this approach and introduce greater flexibility into the organization of French science.

Tax incentives, for example, are going to be raised substantially in an effort to encourage more companies to adopt a less conservative outlook toward new technologies and to invest their own funds in R&D. At present, according to officials from the Ministry of Research and Technology, French industry only supports 43 percent of the nation's civilian research effort, compared to 60 percent in West Germany and 65 percent in Japan.

A special effort will be made to reduce the bureaucratic barriers, such as the time-consuming form filling and report preparation, that has blunted the effectiveness of recent efforts to increase cooperation between university and government scientists on the one hand, and private companies interested in exploiting their research on the other.

A major thrust of a new "scientific employment policy" to be developed within the framework of the new law will, according to research minister Curien, be aimed at encouraging a far greater movement of scientists, whether between disciplines, between different professional sectors, or between laboratories in different European countries.

One novel way of encouraging a greater interchange of ideas, for example, will be to offer employees in private companies the possibility of spending a year working in a public laboratory, along the same lines as they might currently seek time off for pursuing their education.

The new law is expected to say little about developing the government's previous interest in democratizing scientific institutions. For example, there are no plans to repeat the national research colloquium held in early 1982, and consultation with the research community in drawing up the main provisions of the new law has been primarily restricted to the existing advisory machinery and to top research administrators.—**DAVID DICKSON**