Hot Fusion: A Meltdown in Political Support

DOE's magnetic fusion energy research program is limping along, its future uncertain; Congress is sharpening the knife

THE UNITED STATES has spent $6.1 billion over 35 years trying to figure out a way to replicate the sun's fusion reactions in a power plant on Earth. But the task has turned out to be more costly and difficult than many plasma physicists and engineers engaged in the effort ever imagined—so much so that support for the magnetic fusion research program is fading badly in Congress and the Administration.

For the second year in a row, key leaders in the House and Senate appropriations committees are talking about cutting funding for the Department of Energy's $320-million fusion research program—this time by perhaps $20 million. Cuts of that magnitude could force DOE to terminate its existing machines and research projects.

But the fusion program is facing more than a short-term funding crisis. Its long-term goals and plans are under review in both Congress and the Administration. And the program isn't likely to find much solace in Energy Secretary James Watkins, who says he believes the technology has been oversold at times. In fact, in early March Watkins established a new Fusion Policy Advisory Committee to help him map out a fresh set of goals for fusion research. At issue: should the United States embark on an aggressive program to build a working power reactor, make do with existing experimental machines until perhaps 2000—and forfeit its technological lead—or retreat to a basic research mode concentrating on plasma physics?

Just what new course DOE will wind up setting for magnetic fusion is hard to say. But the research program has already been in a state of turmoil for 18 months and recently has been left to drift without a designated captain or a clear mission. And Watkins, who figures that commercial fusion power will not be achieved before 2025 or even 2050, is not rushing to shore up congressional support before House and Senate appropriations committees make their funding decisions. Instead, aides say Watkins will likely defer taking any action until September when his advisory committee completes its review.

Not surprisingly, all this frightens fusion supporters. And they are not prepared to sit on their hands and wait for the committee's verdict. Researchers and industry lobbyists have begun to mount a campaign designed to convince legislators of the merits of the program. Their immediate goal is to head off congressional budget cutters, but their long-term objective is to build support for accelerating the pace of the U.S. fusion effort.

Their work will be cut out for them. Congress really began to sour on magnetic fusion last year when the former director of the Office of Energy Research, Robert O. Hunter, Jr., launched a bold but controversial effort to restructure the program (*Science*, 21 June 1989, p. 1434). He removed the director of DOE's Office of Fusion Energy, put plans to build a new $700-million tokamak reactor on hold, and tried to set up a competition between magnetic fusion and laser-driven inertial confinement fusion (ICF)—a nuclear weapons technology that is generally considered even less mature as a prospective energy producer.

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—Gerald Kulsinski

Hunter, a Reagan appointee, left DOE in November 1989 because his maverick management style proved to be too controversial for the Bush Administration. But his ideas live on. In a recent interview with *Science*, Watkins supported Hunter's central notion of setting up competition in the program. "We just have to open our minds to a new R&D race and not just continue to go after [magnetic fusion] alone," said Watkins. Although Watkins said he is wary of fusion scientists "coming into my office in their black capes telling me how the other guys are wrong," he thinks it will be possible to decide by 2000 whether ICF or magnetic fusion is the most promising technology for a power reactor.

In any case, Watkins says he is convinced that there is a need to inject some "excitement" into the research endeavor and to strengthen congressional support. His stance, he says, reflects "the views of a lot of people on [Capitol] Hill who almost feel as though we ought to kill that program."

Even supporters of the program such as Representative Thomas Bevill (D–AL), chairman of the House appropriations subcommittee on energy and water, are beginning to have doubts. Bevill says his committee is "getting very concerned about the costs" of the effort and about the confused signals Congress is receiving from DOE. And Senator Bennett Johnston (D–LA), chairman of the Senate appropriations subcommittee on energy and water, pointedly warned DOE officials during a 21 March hearing that "as we have to find money, I'll tell you that [magnetic fusion] is one place we have got to look at very carefully."

If this congressional knife-sharpening is a prelude to another round of surgery, the department could be forced to shut down one or more of the six core experimental fusion facilities* it is now operating and to consolidate research activities at other locations. Smaller programs at Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and other sites that are exploring alternatives to the tokamak may be the most vulnerable in the near term.

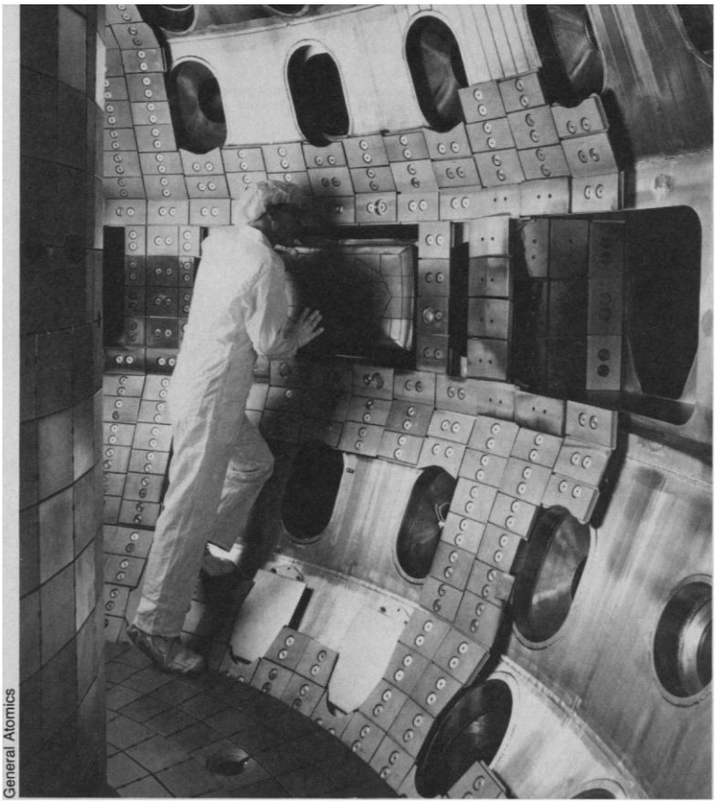
For the past several years, the fusion program has been able to cope with budget cuts by laying off personnel and stretching out experiments. But Ronald Parker, director of the Massachusetts Institute of Technology's Plasma Fusion Center, says that with further cuts, the program "is going to come to a critical juncture where that strategy really does not work, because the program is getting weaker and weaker." Gerald Kulcinksi, director of the University of Wisconsin's Fusion Technology Institute, agrees: "If the magnetic fusion program gets hit for $20 million, then I am afraid it will mean concentrating our research resources."

Research directors already are putting off upgrading their machines or are operating them less frequently. For example, the nation's second most powerful tokamak, Doublet III-D in San Diego, which is managed for DOE by General Atomics, will run for only 14 weeks this year compared to 26

*DOE's six core fusion experimental facilities are the: Tokamak Fusion Test Facility and the Princeton Beta Experiment—both at the Princeton Plasma Physics Laboratory, Doublet III-D at General Atomics, the Advanced Toroidal Facility at Oak Ridge National Laboratory, Confinement Physics Research Facility at Los Alamos National Laboratory, Alcator C-Modified at the Massachusetts Institute of Technology, and Microwave Toroidal Experiment at Lawrence Livermore National Laboratory.

weeks in 1989, says director Thomas C. Simonen. The reason: Simonen needs to save enough money to add diagnostic equipment and upgrade microwave power for plasma heating so that researchers can perform new experiments in 1991.

A similar situation exists at Oak Ridge National Laboratory, where DOE has built a new $20-million stellarator. This steady-state machine can perform some physics studies more readily than tokamaks because there is no need to inject large amounts of signal-distorting current through the plasma as with a conventional tokamak. While Oak Ridge researchers are operating at close to full capacity, they are unable to upgrade the machine's power supplies so they can proceed into the next phase of experiments.



Idle fusion reactor. *A technician inspects heat shielding tiles on the outside wall of the Doublet III-D tokamak at General Atomics in San Diego, California.*

Faced with these constraints, the fusion research community, which last year was divided and feuding (*Science*, 14 April 1989, p. 138) about the timing and location of the proposed $700-million Compact Ignition Tokamak (CIT), has begun to unite around a campaign to persuade Congress and the Bush Administration to get behind the program. On 23 March, Rulon K. Linford of Los Alamos presented a plan to Watkins' Fusion Policy Advisory Committee that was drawn up by an ad hoc group of lab directors. It calls for spending $18 billion (in 1990 dollars) between now and 2020 on an aggressive research program culminating in the construction of an electricity-producing fusion power demonstration plant.

While not endorsing this plan, Senator Pete Domenici (R–NM), a long-time booster of fusion research at Los Alamos, has urged Watkins to "be futuristic" and strongly support fusion energy development in his draft energy policy strategy which is due to be released in a few weeks. "We have got to bite the bullet here or we are going to be buying our technology from abroad," says the University of Wisconsin's Kulcinski. "The decisions that are going to made by Congress and the Administration in the next few years will determine whether we stay out in the lead."

Kulcinski's view is supported by a report issued last month by the Foreign Applied Sciences Assessment Center, a government think tank operated by Science Applications International Corporation. "If present trends continue in the areas of fusion nuclear technology and materials and plasma technology development, the capabilities of Japan and Western Europe . . . will surpass those of the United States by a substantial margin before the middle 1990s," the report concludes. Europe and Japan are pouring more funds into research and they have built more powerful tokamak reactors.

These conclusions come as no surprise to Stephen O. Dean, president of Fusion Power Associates. He notes that the country's top research reactor, the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory, is quickly reaching the end of its useful life. Designed 15 years ago, the machine has produced record plasma temperatures in excess of 100 million degrees and is close to producing as much energy as it consumes. But TFTR does not have the capabilities of the newer Joint European Torus or Japan's forthcoming JT-100 tokamak.

To keep the United States competitive in the field in the mid-1990s and early years of the next century, the fusion community is pushing to build the CIT, a device that would be more powerful than the Japanese and European machines. This device would push beyond energy breakeven, allowing physicists for the first time to study burning hydrogen plasmas for short periods and to gather data that could ease the engineering requirements and cut the costs of a still more ambitious "energy test reactor." But DOE has deferred construction on the grounds that additional studies on plasma physics and heat loss are needed to minimize the risks associated with building this experimental machine.

The only other major new fusion experiment on the horizon for the United States is the International Thermonuclear Energy Tokamak, a $4-billion reactor that would enable physicists to study burning plasmas and test reactor materials for extended periods of time. For almost 5 years the United States has been involved along with Western European countries, Japan, and the Soviet Union in a design study for this so-called energy test reactor—the forerunner of a full-fledged fusion power reactor.

By year's end DOE must decide whether to proceed into the detailed design phase of the multibillion dollar project. But even if DOE goes ahead, the $40-million design exercise will not be enough to keep U.S. fusion capabilities on a par with Europe and Japan. Not only will both these countries be able to squeeze more research out of advanced existing machines, says Dean, but they are maintaining strong research efforts in fusion technology while the U.S. program is steadily shrinking.

"Congress has to recognize that any further cuts will severely damage the program and mean that reaching our goals is going to take that much longer," says John Sheffield of Oak Ridge National Laboratory, who argues that in reality the U.S. fusion program is performing "very well." To get Congress to focus on these issues, Robert Roe (D–NJ), chairman of the House Science, Space and Technology Committee, is planning to introduce a bill that would set out funding and technical milestones to build a fusion power plant by 2020.

But with DOE already saddled with mounting construction bills for the Superconducting Super Collider and four other major projects and the Administration showing only lukewarm interest in the program, it may be some time before fusion can expect a major upswing in funding. Even if the fusion budget remains intact, some consolidation within the research program would seem to be unavoidable if the research effort is to move forward. Comments one lobbyist, "As it is now, everyone is bleeding to death." ■ **MARK CRAWFORD**