Congress cuts magnetic fusion budget, so DOE orders cutbacks

The screws are being turned on the US magnetic fusion program, the largest single energy research effort funded by the Reagan administration. Congress whacked $43 million from the proposed $483-million budget for magnetic fusion in fiscal 1985, which began 1 October. To justify the cut, Congress cited a need for budget restraint as well as a lack of interest by the White House Office of Science and Technology Policy and some fusion scientists in moving rapidly to demonstration projects. The budget cut will have a wrenching effect on the program, as the Department of Energy:

- Postpones plans to achieve a 1986 fusion energy "break-even" through deuterium–tritium burning experiments. These experiments, lasting as long as 5 minutes, were intended for the Tokamak Fusion Test Reactor at Princeton. They will probably be delayed by at least two years.
- Delays scheduled completion of the Mirror Fusion Test Facility at Lawrence Livermore Laboratory from fiscal 1988 to 1989 or 1990.
- Reduces several research programs—particularly those in nuclear technology and materials—with the probable result of shutting down some physics experiments. These include the Elmo Bumpy Torus at Oak Ridge—once the best-funded DOE alternative to TFTR and MFTF—and the Princeton Large Torus. Moreover, the future of the Fusion Materials Irradiation Test project at Hanford is contingent on international collaboration with Japan.

In addition to these retrenchments, the program will absorb an additional loss of $3 million in DOE expenditures for computers. Some of it is certain to come from the National Magnetic Fusion Energy Computing Center at Livermore. What's more, prospects for proceeding with the Tokamak Fusion Core Experiment, which was budgeted $10 million in the 1985 request to Congress after being recommended last February by the DOE Energy Research Advisory Board, are now so dim they're at the point of vanishing.

For Alvin W. Trivelpiece, director of DOE energy research, the effect of the budget cut is like Samuel Johnson's famous remark about the sight of a hangman's noose concentrating the mind. "There were some difficult decisions to make, and these were not taken lightly," says Trivelpiece. "The budget reductions will result in delays in project schedules, but the scientific objectives remain intact. We have expended a great deal of time, talent and money to design and fabricate the devices necessary to develop the physics of linear and toroidal systems. It would be folly not to exploit the physics capabilities of the machines."

A joint $10-million agreement to test structural alloys for fusion reactors was signed in 1983 by DOE's John Clarke (left) and Tsuneo Fujinami of the Japan Atomic Energy Research Institute.

Program centerpiece. Though TFTR, the centerpiece of the fusion program, will suffer a $9-million reduction, "it still enables us to do the critical hydrogen experiments with greater efficiency and less inconvenience than would be the case in using tritium," says Trivelpiece, "because that would involve remote handling." The cuts mean that the operating budget of MFTF-B will go down $15 million and that the technology programs, including design studies for future fusion machines, will drop $12 million. The tokamak at the Oak Ridge ISX facility will be closed and replaced with a stellarator. Both the FMIT at Hanford and the applied plasma physics program will be cut by $3 million.

"I don't like making cuts in technology programs because it's simplistic to think all good science in fusion is being done only by plasma physicists," says Trivelpiece. " Much of our technology development is outstanding 'science' in the broad meaning of the term."

Trivelpiece admits that the budget cut was Congress's way of warning DOE that the fusion program "has not adjusted to the realities of the present situation in energy supplies and the escalating costs of hardware. The goal of fusion energy is still distant, but for the present we have a program that is at the forefront of many fields of science and technology. We intend to emphasize the excellence of research, which has gotten somewhat lost in all the rhetoric about fusion as the potentially inexpensive and inexhaustible source of energy."

Ironically, Congress had been among the staunchest advocates of fusion. In 1980, a year after the Iranian revolution brought another crisis in world oil supplies, Congress passed the Magnetic Fusion Engineering Act, calling for a demonstration of the feasibility of sustained fusion burning by 1990, and a fusion power plant producing electricity by 2000. The law did not provide funds to make the timetable come true. To do that, Congress has to appropriate money each year and usually adds funds to DOE budget requests for fusion. This year things were different.

In contradictory actions in the House, the authorizing Energy Re-

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search and Production Subcommittee favored an increase of $9.2 million for magnetic fusion, while the Appropriations Subcommittee had other ideas, recommending a cut of $64 million from President Reagan's requested $483 million. The report of the House Appropriations Committee, headed by Representative Tom Bevill of Tennessee, noted caustically: "It is the sense of the committee that the fusion program is somewhat earlier in its development cycle than was predicted for this time 10 years ago." It went on to state: "The Secretary of Energy has testified in the past that fusion energy is not commercially viable for another 40 to 50 years [and, therefore, the members express concern] about the very long-term commitment of vast amounts of funding necessary to prove the scientific feasibility of fusion." Fusion was a less easy target in the Senate, which proposed a $13-million cut. But, in conference, a compromise was reached on a $43-million "general reduction," leaving to DOE the painful job of making specific cutbacks. The funding bill also directs DOE to "seek international collaboration and financial participation in future large-scale research devices" for the fusion program. In addition, the bill states that the conferees "concur in the Senate report's language requiring a new comprehensive program-management plan and direct that no funds be available for other conceptual analysis activities related to fusion concepts not currently funded in the magnetic-fusion program."

With that statement ringing in his ears, Trivelpiece is rethinking the future of magnetic fusion. "I'm confident that fusion is scientifically and technically possible," he observes, "and that it will be an important future energy option. In the near term we must continue to pursue research to find better ideas, and I intend to expand our support of other concepts to develop the most promising approach to fusion. At the same time, there is plenty of evidence that the tokamak provides just as good a starting point for improvement and innovation as other concepts. It is a standard and a challenge for those who advocate other concepts."

Joint research. As for international collaboration, Trivelpiece says this is already underway with Japan, which shares 50–50 in the Doublet project at GA Technologies in San Diego. In 1983, DOE signed a five-year agreement with Japan's Atomic Energy Research Institute to share the costs of collaborating on tests of structural alloys for fusion reactors, using high-intensity neutron research facilities at Oak Ridge. In the current fiscal year, US collaboration with Japan is likely to increase through the JT-60 project—and through design studies for a burning-core experiment.

Moreover, it was clear to political officials who met in Brussels in July, after the economic summit of Western nations in London a month earlier, that research facilities costing $1 billion or more cannot be duplicated in those countries. "Fusion is one of 18 areas in science and technology that those at higher political levels consider appropriate for international cooperation and collaboration," says Trivelpiece.

It didn't take DOE long to comply with Congress's demand for a new program strategy. It was unveiled in draft form under the title "Magnetic Fusion Policy Plan" on 3 October by John F. Clarke, associate DOE director for fusion energy, at a conference of Fusion Power Associates held in Rockville, Maryland. For the next two days, it was the main topic of the Magnetic Fusion Advisory Committee, which met with experts in the field at DOE headquarters. Clarke emphasized that the goal of the program continues to be the development of the scientific and technological base for an acceptable fusion energy program. Among the plan's key elements:

- Commercialization of new and alternative energy sources, particularly fusion, "is the responsibility of the private sector and not the Federal government." This statement endorses the Reagan administration's philosophy of government-funded R&D, which requires that the program provides the basis for commercialization.
- DOE managers will carry on a "balanced" fusion program that combines the scientific richness of fusion—with the goal of achieving fusion energy at some time in the future. DOE is required to foster new ideas and approaches from laboratories, universities and industries, as well as to stimulate the training of talented scientists.
- International collaboration must be cultivated to advance the scientific knowledge base for fusion and to plan and build new facilities—factors that will reduce the cost and risk.
- "Minimize program costs wherever possible by utilizing existing facilities and upgrades, by drawing on science and technology advances in other fields and by taking advantage of the transferability of fusion science and technology—that is, using knowledge gained from one configuration in others."
- "Address the scientific issues of fusion in depth through the production and study of well-confined, high-temperature plasmas utilizing facilities of appropriate size and scope."

In connection with scientific understanding, the plan calls for studies of the behavior of a long-pulse, ignited-fusion plasma as well as of plasmas in a variety of configurations. The strategy includes at least one long-pulse fusion machine—presumably the postponed fusion core experiment—and new or upgraded facilities that will be chosen within the next five years "on the basis of deliberate technical evaluations."

"The principal technological issues relate to magnetics, heating, energy removal, fuel generation, behavior of materials in the fusion environment and safety," says the draft plan. "These matters need to be examined under realistic conditions within fusion facilities.... Currently, the technology program is supporting existing scientific experiments," the plan continues. In addition, the technology program is supporting the development of superconducting magnets (at the International Fusion Superconducting Magnet Test Facility at Oak Ridge), materials behavior (at the Rotating Target Neutron Source-II at Livermore) and tritium handling (at the Tritium Systems Test Assembly at Los Alamos). The plan recognizes that new facilities will be needed to advance technology unique to fusion, such as energy removal, fuel generation and behavior of materials in the fusion environment.

Contradictory positions. Emphasis on a balanced program leading to the joint international development of technology and eventually to commercial power has been a concern of the White House science office and Energy Secretary Donald P. Hodel, who spoke vigorously at the Versailles summit conference for the joint participation of Western nations . The architect of US policy is George A. Keyworth II, who led the laser fusion program at Los Alamos before becoming President Reagan's science adviser. His position was enunciated in 1982 by John Marcum, assistant director of Keyworth's office for energy and natural resources. "We are spending nearly half a billion dollars a year on fusion, which is the most challenging project man has ever undertaken, including the Moon landing and the Manhattan Project," said Marcum. "Yet we don't expect to generate significant quantities of commercial electricity until the middle of the next century. Devices will cost in the billion-dollar range, and several different prototypes will have to be built before we find the one that is most practical.... Let's face it, the United States, Japan and Europe can't afford to build their own tokamaks, stellarators and tandem mirror devices."

More recently, at an MFAC meeting at Princeton on 18 July, Ralph DeVries, OSTP assistant director for general science, restated the White House stand on fusion. He criticized the DOE explanation of the program that accompanied its budget request for

fiscal 1985, observing that only the applied-physics section makes the effort sound like good science. He said that the description of confinement systems, development technology and planning sounds suspiciously like programs aimed "explicitly toward the definition, construction and operation of large reactor-like machines." This is a goal the Administration does not include in its current plan.

The message from the White House was not lost on Congress when the DOE budget came up for approval. —IG

Vogt panel endorses SURA accelerator

Room 542 at the National Science Foundation was jammed all afternoon of 24 September for another episode in a long-running drama that has acquired the title "The Saga of SURA." The latest act was played in front of physicists from universities, laboratories and professional societies, aides to members of Congress and officials of government agencies who crowded into the narrow conference room to hear the report of a subcommittee of the Nuclear Science Advisory Committee. NSAC had been asked by President Reagan's science adviser, George A. Keyworth II, to reexamine the scientific merit of its recommendation to build a cw electron accelerator with an energy range of 0.5 to 4 GeV. The machine became an object of controversy 20 months ago, when NSAC advised the Department of Energy to select the proposal for it submitted by Southeastern Universities Research Association over concepts advanced by other groups—namely Argonne, Bates Laboratory at MIT, National Bureau of Standards and University of Illinois (PHYSICS TODAY, July 1983, page 57).

A crucial act took place last June when Congress appropriated $3.5 million of $5 million that DOE requested for R&D and engineering design studies for the continuous-electron-beam accelerator facility, or CEBAF, as SURA calls the machine, but agreed "to defer, without prejudice," any construction funds in fiscal 1985. According to Congressional staffers and DOE officials, the reasons for this were scientific and technical, involving questions about the energy range and importance of CEBAF. In cutting the CEBAF request for fiscal 1985, Congress expressed concern about the priorities of the nuclear science community for future facilities, as given in NSAC's most recent *Long-Range Plan for Nuclear Science* (PHYSICS TODAY, September, page 55). By calling on NSAC to review CEBAF again, Keyworth, DOE and SURA hoped to end the uncertainty once and for all.

Before the subcommittee delivered its conclusions, chairman Erich Vogt of the University of British Columbia explained that the considerations governing the CEBAF issues were "somewhat broader than a simple yes-or-no decision." The group, which included NSAC chairman John Schiffer of Argonne, Gordon Baym of the University of Illinois, D. Allan Bromley of Yale, Glennys Farrar of Rutgers, Steven Koonin of Caltech, John Negele of MIT, Ingo Sick of the University of Basel and Dirk Walecka of Stanford, worked from about mid-July to mid-September "coupled," said Vogt, "with VAX computers." In the end, the subcommittee reached unanimous agreement on the need for cw electron beams. But "after considerable and lively discussion," Vogt observed,"only a majority supported 4 GeV as the right energy reach."

Kinematic flexibility. The precise energy range of the machine similarly perplexed two previous NSAC groups—the Subcommittee on Electromagnetic Interactions headed by Peter Barnes of Carnegie–Mellon University in 1982 and the Panel on Electron Accelerator Facilities under Bromley's chairmanship in 1983. In its succinct 10-page report, the Vogt subcommittee states: "There is no known sharp threshold for new physics above 2 GeV, but one gains kinematic flexibility, which can increase both the rate at which the experiments can be carried out and the information they provide . . . In assessing the priority to be given the full energy, the subcommittee considered again the list of experiments and the kinematic diagrams the Barnes Panel provided in its report. Doing this, we found that the physics dealing with nucleons, nucleon resonances and mesons either is or begins to be accessible by 2 GeV. This includes determination of nuclear and nucleon multipole amplitudes, the study of deep-lying hole states, the nucleon spectral function in nuclei, two-body correlation functions through one- and two-nucleon knockout and the study of pion and delta propagation in the nucleon medium through coincidence experiments. . . ."

McCARTHY

"For those of you who came here expecting a bloodbath for electromagnetic physics," said Vogt, "this must be very disappointing." The report emphasizes the unity of nuclear physics, in which electromagnetic studies are essential in addressing a broad range of fundamental open questions in nuclear physics and its interface with quantum chromodynamics. Accordingly, the report hails the 4-GeV CEBAF as the "accelerator of choice," the "first-priority major construction project for nuclear physics. . . . We view this facility as the major component of a structured electromagnetic research program providing world-leading new capabilities for exploring atomic nuclei, particularly the effects of nucleon substructure." The review of the machine is limited to its physics. The Vogt group was enjoined by Keyworth from commenting on matters of design, technology, cost, site and management.

Complementary components. Though the major part of the report deals with the problems confronted by SURA, the subcommittee could not resist the temptation to restate some conclusions of the NSAC *1983 Long-Range Plan*. Thus, while the 4-GeV accelerator is "the central component of a structured program of electromagnetic research," the report speaks of "complementary" components of a world-leading approach to nuclear science. These include: building a 1-GeV cw facility that offers high resolution and would be relatively inexpensive; vigorous use of the existing 20-GeV electron beam at SLAC; experimenting with the 900-GeV muon beam (nearing completion at Fermilab), which will permit exploration of nuclei in the realm of asymptotic QCD. Beyond these, the subcommittee calls for a relativistic heavy-ion collider, as did the NSAC *1983 Long-Range Plan*. Only this time it made sure no reader misunderstood its ranking of priorities.

After the Vogt Report was fully aired, CEBAF director James S. McCarthy heaved a sigh of relief but remained wary. "I've learned to accept the ups and downs of the SURA machine," he said. "Just when I think everything is up, something comes along that changes things. I'm encouraged by the Vogt Report, but I know there's still a long way to go." —IG □