What Course for U.S. Fusion Energy R&D?

Long-term progress hinges on higher funding for fusion research. Can the program win support in the 1990s for a major experiment built and run with international partners?

DURING much of the 1980s, America's magnetic confinement fusion program has been in a holding pattern. The purpose of the federal research program is to develop a new generation of nuclear reactors that could provide a limitless supply of energy. But construction of major next-generation nuclear fusion experiments has been deferred and researchers have continued to make scientific progress with existing machines. At the same time, the scope of the program has narrowed as some experiments have been slowed or closed.

The strategy of delaying capital expenditures and containing program spending cannot last much longer if the United States is going to move forward, according to a study in the final stages of preparation by a branch of Congress. In a draft copy of "Starpower: The U.S. and The International Quest for Fusion Energy," the Office of Technology Assessment (OTA) says that the Executive Branch and Congress face critical decisions in the mid-1990s on the course of the fusion program.

A key issue is how and whether to proceed with an international project to build an energy test reactor capable of igniting and burning a hydrogen plasma contained within a magnetic field. Such a device would be the forerunner of a prototype reactor to fuse hydrogen atoms to produce energy that would be extracted to generate electricity. The options before policymakers then, OTA notes, also may include cutting back the American fusion R&D effort or even mothballing it. Depending on budgetary pressures, the energy outlook, and other variables fusion's importance could diminish, OTA says.

The concept of international collaboration has been pursued by the Department of Energy (DOE) because of its potential for holding down costs and reducing the risk of failure. OTA notes that cooperation in fact is essential for a "challenging, growing U.S. fusion program." The cost of this preprototype device could run as high as $4 billion (*Science*, 23 May 1986, p. 925).

Since late 1985, when President Reagan and Soviet General Secretary Mikhail Gorbachev agreed to expand international cooperation in fusion research, DOE has pursued the concept of building a burning plasma test reactor in conjunction with the European Community, Japan, and the Soviet Union. Previously, department discussions on international collaboration included only the Europeans and Japanese.

The notion of working with the Soviets on such a project, however, set off alarms at the Pentagon. Department of Defense officials asserted that the militarily sensitive technology could be transferred to the Soviets. DOE officials have maintained that technology transfer problems are manageable, but the White House has not yet settled the feud.

DOE officials have managed to sidestep this controversy for now by proposing that multilateral cooperation be limited initially to the conceptual design of what is being called the International Thermonuclear Experimental Reactor (ITER). There is no firm agreement as yet to proceed with this first phase. Representatives of the four parties are slated to decide in October whether to recommend that their governments participate in the conceptual design exercise.

Even if this occurs, it will not commit any country to proceed to build ITER, or require that all four parties participate in the second phase. Indeed, OTA observes that the national security debate continues to smolder and will not be "easily resolved." Without presidential intervention, OTA adds, "It appears that the United States will not be able to participate in a major joint undertaking with the Soviet Union."

The advantages of proceeding with an international device are not clear-cut. OTA notes that it is unlikely that such a device will be located in the United States or the Soviet Union. As a result, the economic benefits to American industry would be somewhat less than if the United States were to proceed independently. Total costs for the project likely could be significantly higher than if one country undertook ITER itself and the project probably would take longer to put in place, OTA notes.

No matter what the United States does, the domestic fusion program must have more money if it is to move ahead. "At current funding levels and as presently structured," says OTA, "the U.S. fusion program cannot construct and operate essential experimental facilities on its own without dramatic curtailment of other necessary aspects of the fusion effort."

DOE's fusion budget fell from a peak of $468.4 million in fiscal year 1984 to $345.3 million this year. Since 1983 overall spending, after adjusting for inflation, has been dropping. Although fusion has fared better than some other R&D programs at the department, the budget cuts have forced scientists out of the program, curbed R&D support for alternative fusion concepts, curtailed university involvement, and reduced industry participation. It also has resulted in the closing of a new, untried $360-million fusion machine at Lawrence Livermore National Laboratory—the Mirror Fusion Test Facility—OTA notes.

The decline of the magnetic confinement fusion program is somewhat distressing, OTA indicates, because the effort's impact reaches beyond the drive to prove the feasibility of making a fusion reactor. "The program trains far more people than it employs, and these people make valuable contributions in a variety of fields other than fusion," the report says.

If funding for fusion continues to erode, the pool of scientists and engineers affiliated with the program will shrink further, OTA says. The number of staff with doctorates already has declined almost 20% since 1983, according to DOE estimates. Similarly, half of the 40 or so universities involved in the program could withdraw by 1989, according to one analyst.

What Congress will do in the next decade is hard to say, but there are signs that it is not ready to see the nation's fusion program lose too much ground. The House Appropriations Committee has provided $19 million ($13 million more than was requested) to start construction of the Compact Ignition Tokamak (CIT) at the Princeton Plasma Physics Laboratory. It is designed to go beyond the energy break-even test scheduled to take place in 1989 at Princeton's Tokamak Fusion Test Reactor. The $357-million CIT is designed to achieve ignition of a hydrogen plasma, whereas ITER would allow burning plasmas to be studied for a sustained time.

Whether support will be forthcoming from the Administration and Congress in the next decade for a major new fusion experiment in the United States or as part of an international collaboration is uncertain. The case cannot be argued, OTA notes, on the basis that a crash program to develop

fusion power reactors is needed in the immediate future. "It is very difficult to formulate a credible scenario of major irreversible electricity shortages in the early 21st century that would require fusion's development on an accelerated schedule," says OTA.

On the other hand, the agency adds, Congress must weigh the potential effects of the United States falling behind the rest of the world. The European Community appears ready to build its own version of ITER, the "Next European Torus." Likewise, Japan has plans for a "Fusion Energy Reactor." International collaboration, OTA suggests, would provide the United States with an opportunity to at least stay even with other countries. ■

MARK CRAWFORD

Botany Bids for the "Big Science" League

A multimillion dollar proposal to catalog the flora of North America has caused some strife among botanists

NANCY R. Morin, a scientist at the Missouri Botanical Garden, and two dozen other leading American and Canadian botanists have scoured the world looking for rare plants, but they have yet to find the one they need most these days—a money tree.

Morin and colleagues in the botany community have banded together to conduct the first inventory of the entire flora of North America, an enormous task that will take more than a decade to complete. They plan to fill 11 volumes with information on some 17,000 species of plants, forming taxonomic dossiers on each plant with a list of its various names and descriptions of its looks and location. The information will be used also to create the most elaborate online computer database on plant taxonomy to date.

But there's one major hitch: the scientists pushing the multimillion dollar project have barely enough money to get it off the ground. Project leaders have applied twice now to the National Science Foundation for funding, but have so far been unsuccessful. Undaunted, the botanists are volunteering their time and effort to put together the first volume in hopes that more interest and financial support will eventually be generated.

Supporters of the project, known as the "Flora of North America," say that the information will provide botanists with an important scientific tool for research. It will also help in conservation efforts and land management, they say. "We need to know baseline information" about North American flora, says Morin, who is curator of the herbarium at the Missouri Botanical Garden and coordinator of the project. "We can't monitor change if we don't know what's out there to begin with."

They note that the botanists' Bible for the flora of the Northeast, *Gray's Manual of Botany*, written by Harvard's Asa Gray almost a century and a half ago, was last revised in 1950. And, they like to point out that the Soviet Union and Europe have already inventoried their own biota, and China and Australia presently have surveys under way.

The Flora of North America project has substantial scientific support. The American Association of Plant Taxonomists and the Canadian Botanical Association have passed resolutions supporting an effort to catalog the plants in the United States and Canada, for example. The Nature Conservancy backs the project, although it does not make grants. And scientists volunteering to help include many luminaries in the botany community, such as Theodore Barkley of Kansas State University, David Boufford of Harvard, Marshall Johnston of the University of Texas at Austin, John Packer of the University of Alberta, and John Thieret of Northern Kentucky University.

But some scientists, though they support the project in concept, worry that its enormous cost might divert research money from other important work with plants, particularly in the tropics. "To what extent does the project divert systematics from other useful projects? Who will pay for it?" asks Harvard botanist and tropical specialist Peter Stevens. Still others say they are not confident that the plans for the complex computer data bank have been fully thought out.

Morin acknowledges that the project is expensive. She calculates that the survey needs $500,000 annually for 12 to 15 years. This would cover the work of contributors, the development of the computer database, travel to scientific meetings, and overhead costs. Though $500,000 may be a drop in the bucket for other scientific projects (the price tag of the Continuous Electron Beam Accelerator Facility at Newport News, Virginia, is about $250 million), the amount represents a big chunk of money in the botany community.

Morin says she will submit another funding application to NSF this fall. Earlier this month, at an international botanical meeting in Berlin, NSF officials say they encouraged Morin to keep trying.

Lee Fox

Nancy Morin: *"It's very frustrating not to be able to go to one place" for botanical information.*