Fusion Energy Project Moves One Step Closer

The United States has rejoined the long-term ITER Project, the world's main hope for fusion energy's vast resources and potentials. Marsha Freeman reports from the latest scientific conference.

The recent political row in Washington over the much-hated, porkbarrel-laden energy bill, has obscured the fact that there is important progress being made to develop a technology that promises the world an inexhaustible, concentrated, widely applicable, and universally available form of energy—thermonuclear fusion power. Fusion is the energy of the stars, the fusing together of light nuclei, which releases enormous amounts of energy in the process.

Unlike today's nuclear fission power plants, fusion does not depend for fuel upon geographically local concentrations of resources, such as uranium, but can use isotopes of hydrogen that are found in sea water. Also unlike fission, the energy from the fusion process can take the form not only of highly energetic neutrons—from which heat is extracted to boil water to produce electricity in today's fission reactors—but also of charged particles; and produces an array of different qualities of radiation.

The heat energy from fusion can be used thermally to split water, in order to cheaply produce hydrogen for transportation fuel. Charged particle flows resulting from fusion processes can be magnetically manipulated to produce electricity directly, without energy-wasting turbines and generators. And the application of fusion power to space propulsion will make it possible to transport people to Mars in days, rather than months.

The quest to develop technologies to produce fusion energy has existed, on an international scale, since the period of the Atoms for Peace initiative of President Eisenhower in the 1950s, and the declassification of much of the essential nuclear science—as distinct from the techniques for creating the hydrogen bomb. Individual nations—particularly the United States and the Soviet Union—have expended great effort over decades to try to tame this energy source of the stars.

In 1985, at the first Reagan-Gorbachov summit, the two leaders agreed to collaborate to construct the world's first operating experimental fusion reactor. The proposal had been formulated by Russian fusion scientist Academician E.P. Velikov, and subsequently the European Union and Japan were invited to join. Canada also joined the project, known as the International Thermonuclear Experimental Reactor, or ITER (see **Figure 1**); and this year, China and Korea became participants, as well.

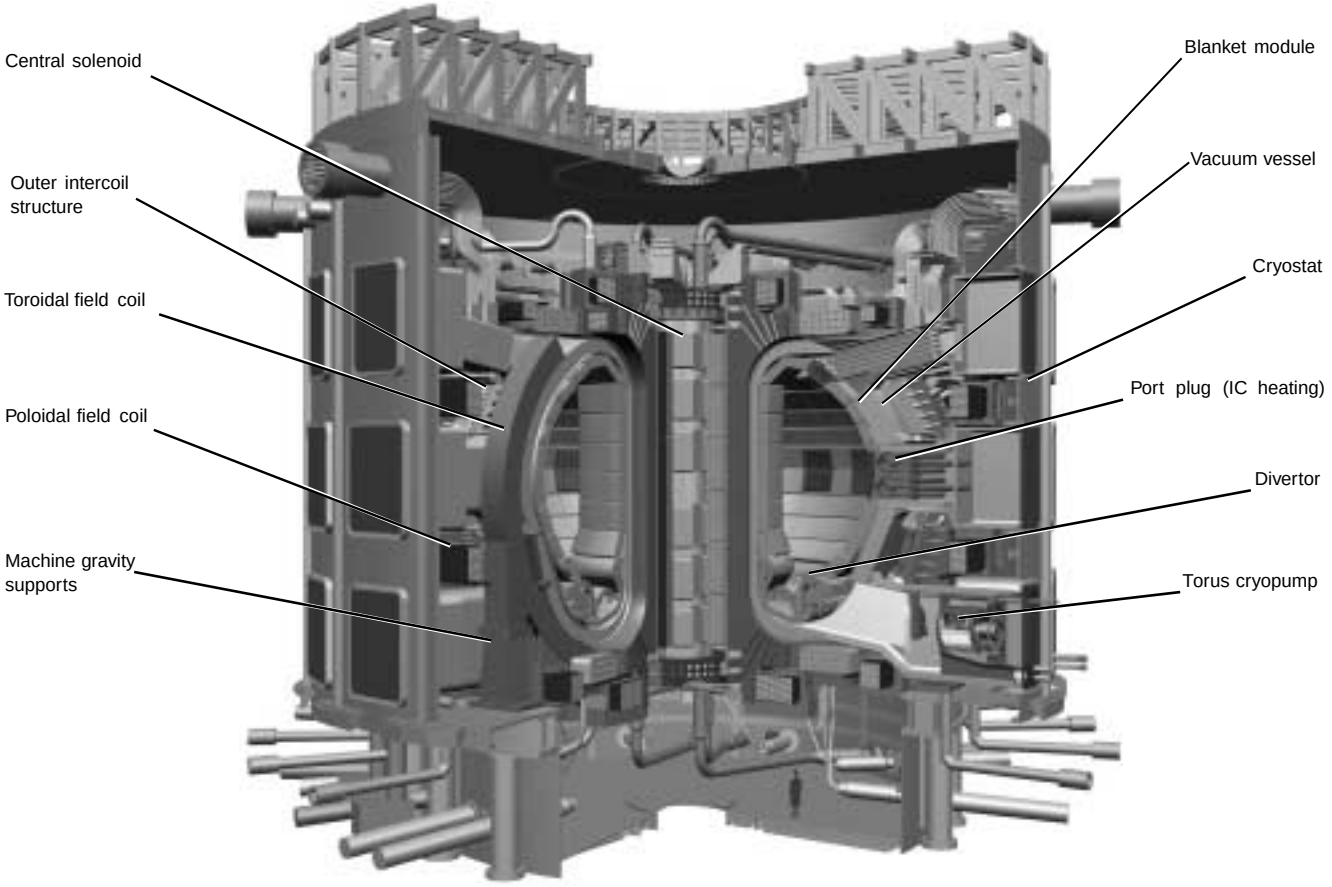
It is as much of a challenge to get the political leaders and the scientists from a dozen nations to agree on the design for a multi-billion-dollar experiment, as it is to heat a plasma to 100 million degrees and force the light nuclei to fuse. There have been a lot of bumps on the road to ITER since 1985. But there is now uniform agreement that the development of fusion as an energy technology is a necessity for the world as a whole; and recently, there have been important steps forward.

Reaching a Compromise

One major bump in the road to progress in the international fusion experiment was the decision by the Congress in

FIGURE 1

The International Themonuclear Experimental Reactor (ITER)



Source: Courtesy of International Atomic Energy Agency

1998 to pull the United States out of ITER. The arguments were not that different than the roadblocks that exist for formulating a policy to develop a manned mission to Mars. ITER was too long-term, too expensive, and probably would not work, it was argued. At that time, international science and engineering teams had designed an ambitious fusion *tokamak* experiment with a price tag of $8 billion.

In 1998, as the engineering teams were re-scoping the project to lower the cost, and against the advice of the Clinton Administration, the Congress decided not to renew U.S. particpation in the ITER six-year Engineering Design Agreement, which all of the other partners had signed.

Over the next four years, hard work by American fusion scientists, positive reports from various national scientific advisory committees, and a lobbying campaign by the international partners—the Japanese, in particular—urged the White House to rejoin ITER.

The official completion of the second-generation engineering design for ITER was announced at a meeting of the International Atomic Energy Agency (IAEA), on July 17, 2001. The IAEA described the work as a "landmark achievement in fusion energy research." It noted that ITER "will be capable of generating 500 megawatts of fusion power"—equal to a medium-sized power-plant unit today—for up to ten minutes, and could "lead to the construction of a demonstration fusion power plant that generates large amounts of electricity." The price tag was cut in half, to $4 billion.

There were signs that the Bush Administration would revisit U.S. participation in ITER. On Dec. 20, 2002, the prestigious National Academy of Sciences issued an interim report recommending "that the United States enter ITER negotiations, while the strategy for an expanded U.S. fusion program is further defined and evaluated." The Academy also warned

that in addition to the international cooperation, "a strong domestic program must be maintained."

On Jan. 23, 2003, an article in the British magazine *Nature* reported that the People's Republic of China had formally asked to join ITER, and offered to contribute 10% of the cost. On Jan. 29, the House Science Committee released a bipartisan call for the Department of Energy to rejoin the project. One reason, they stated, is to ensure that "a new generation of scientists is inspired to work in this area." Cutting the cost of ITER in half—and perhaps the added participation by Korea and China—seems to have convinced the Congress to support the program.

The following day, the White House released a statement by President Bush, who announced that the U.S. "will join ITER, an ambitious international research project to harness the promise of fusion energy," and directed the Secretary of Energy to represent the United States in upcoming ITER meetings. A statement by Energy Secretary Spencer Abraham the same day, during a visit to the Princeton Plasma Physics Laboratory in New Jersey, stressed that the President's "historical decision" in no way "means a lesser role for the fusion programs we undertake here at home." The fusion science community had spent years building a consensus to support ITER, premised on the condition that the smaller and more innovative domestic fusion experiments would not be fiscally sacrificed for the large international project.

Budget-Cutting Threat

But support from the Administration, even when enunciated by the President, does not always translate into action. At the annual meeting of Fusion Power Associates, held across the street from Capitol Hill on Nov. 19, different interpretations of the White House policy for fusion were voiced.

Dr. Ray Orbach, from the Department of Energy's Office of Science, stated optimistically that the "U.S. would play a lead role in ITER," because in addition to support from the White House, there was also "a strong Congressional statement." Dr. Orbach pointed out that on Nov. 10, when Secretary Abraham spoke at the National Press Club and released a report on the facilities needed for the future of science over the next 20 years, ITER was at the top of the list.

Dr. Orbach also pointed out that the "funding envelope needed to build the list of 28 science facilities, led by ITER, over the next two decades, was based on a 4% per year growth in Growth Domestic Product." The plan, he explained, was "what we would do if there were an increase in funding in the physical sciences."

Speaking for the President's science advisory group, J. Patrick Looney from the Office of Science and Technology Policy was a bit less sanguine. While positive about the future of ITER, Looney described it as the "800 pound gorilla in the room," and *the* defining experiment for fusion in the United States. He described the ITER consensus in Washington as "fragile," and said the program would need continuous "political momentum"; the task was to "take the vision and fit it into the budget." Not exactly what the fusion community had hoped for.

Joel Parriott, from the bean-counting White House Office of Management and Budget was even more direct. "If things [ITER] don't work out," he warned, "you can't just go back" to the program the way it was before, indicating all of the fusion eggs are now in the ITER basket. When queried on where the funds would come from to develop the technology the United States will provide for ITER, Parriott made clear such work will have to be done within the current budget. ITER is a science, not an energy program, he insisted, and technology that must be developed to design a power plant should come from somewhere else. He suggested the scientists "prioritize" their requests, and find trade-offs.

So far, neither the Congress nor the White House is willing to fund the fusion program at a level that would allow America's full participation in ITER, nor a broad research and development effort for mainline and innovative smaller-scale fusion experiments—both those already in operation and those planned for the future.

Teamwork

One of the most important decisons that has to be made before construction can begin on ITER is where the experimental fusion reactor will be located. Getting to the point of making this decision has been no easy task.

The ITER partners decided that the host nation will bear the responsibility of preparing the site, providing the transport, energy, and other infrastructure for the construction, and also contribute its proportional share of the total construction cost. It might have been assumed that either the United States or Russia, with the largest, most in-depth, well-staffed, and oldest fusion programs, would have been a shoo-in to host the program. But Russia has not been in a fiscal position to make such a commitment, and the United States was not even a participant in the project for a number of years. America, China, Russia, and South Korea have indicated each will pay 10% of the cost of ITER, and not offer a site.

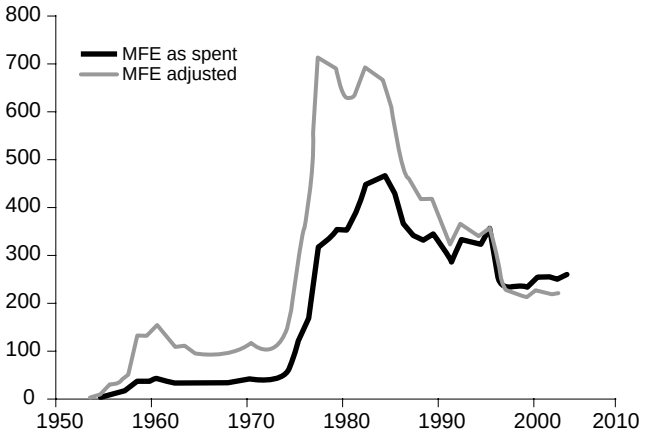
By the Fall of 2001, Canada, Japan, Spain, and France had offered possible sites for ITER. Although the financial commitment for the host country is substantial, so is the pres-

tige. And there is the benefit of hosting international teams of scientists, who can have an impact on the host nation's scientific education, and the training of the construction teams that one day might be building commercial fusion power plants for electric utilities.

The original, self-imposed schedule called for a single European site proposal for ITER to be chosen by September of this year, because both France and Spain had made offers. Finally, on Nov. 26, the European Union announced that France had been chosen as the proposed European site. The site at Caderache is quite attractive and well developed, since it is already a nuclear research center with 4,000 employees and 18 nuclear installations. The local government has also stated it will contribute funds toward ITER's construction.

The other serious proposal to host ITER is from Japan. The location of the site is at Rokkasho-mura, in Aomori Prefecture in northern Japan. Rokkasho is already the site for nuclear fission facilities, and it is planned that it will play a major role in future Japanese nuclear technology. It is also the center of a planned development program being undertaken by Aomori Prefecture, known as a "Base for International Science and Technological Research." Unlike the fusion programs in the rest of the world, Japan's large experimental machines have not been built in government-sponsored national laboratories, but by industry. The government reports that at Rokkasho there are more than 1,000 companies participating in the construction of the nuclear fuel cycle facilities.

FIGURE 2
U.S. Fusion Budgets 1950-2002
(Annual Budget)



Source: Fusion Power Associates.

Budgetary support for magnetic fusion energy research and development—mostly for tokamak designs—has dropped steadily after an apparent national decision for rapid development 25 years ago (solid line). The dotted line shows the even more drastic drop when the funding is adjusted for inflation. Despite the U.S. re-entry into ITER this year, more funding constriction still threatens.

If There Is a Will . . .

ITER is expected to require a ten-year construction phase; an operating phase for the experiment of about 20 years, which could include up-grades; and then a decommissioning phase. The estimated cost of construction is more than $4 billion, and the total cost for all three phases, more than $10 billion.

Before the construction of the International Space Station—whose cost of assembly and operation is an order of magnitude more than ITER—it might have been argued that nations as diverse as Russia, the United States, the European countries, Canada, and Japan could not cooperate to keep a large-scale project alive over decades of time, billions of dollars of expenditure, and changing political environments. But the success of international cooperation building and working on the space station is a useful precedent for future cutting-edge science and technology projects that can most usefully be tackled using all of the resources of the international scientific and technical community.

Over the past two decades, the Federal budget for magnetic fusion energy research in the United States has effectively fallen by two-thirds, when adjusted for inflation (see **Figure 2**). This decline has held back progress in reaching the goal of producing fusion energy for commercial use and non-electric applications. It has demoralized the scientists, often pitting one group of researchers against another, to fight for budget dollars. And research into many promising roads to fusion have been eliminated only due to lack of support.

Support for ITER has come from the top of the power pyramid in Washington—from the President himself. But the perspective from the budgeteers is that there will be little increase in overall fusion funding; that work on ITER will have to be a trade-off with the existing (half-starved) programs. There is also the implicit or explicit threat that if ITER were to fail, that would be the end of the domestic fusion effort.

The International Space Station has so far just barely survived four different American Presidents, various Russian heads of state, and political and budgetary upheaval among *all* of the international partners. Successive American administrations squeezed as much as they thought they could get away with from NASA's manned space programs. The folly of underfunding them came home to roost when the *Columbia* Space Shuttle broke up over Texas last February.

The fate of ITER, and of fusion energy development overall, will now require that policymakers put their money behind the support they have given to it in public statements.