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Will Japan and Europe outstrip the United States' fusion effort?

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Just over four years ago the U.S.'s magnetic fusion Princeton Large Torus tokamak (PLT) experiment reached record temperatures for a fusion device—over 60 million degrees. On the basis of that exciting breakthrough in fusion research, the federally funded fusion programs in the United States, Japan, and Western Europe were reviewed by panels of scientific experts to evaluate whether the timetable for demonstrating the commercial feasibility of fusion should be moved forward.

The unanimous conclusions of those reviews was a resounding "yes." In the United States, the Congress passed the Magnetic Fusion Energy Engineering Act of 1980 with the goal of demonstrating the engineering feasibility of magnetic fusion by 1990 and commercial feasibility by the year 2000. The European review gave a full go-ahead to the Joint European Torus, now under construction at the Culham Laboratory in England and scheduled for operations next year, and recommended that design work on the Next European Torus commence. In Japan, the Atomic Energy Commission has just completed its formal five year plan and has outlined a timetable to demonstrate engineering feasibility by the early 1990s and commercial demonstration in the first decade of the next century. These recommendations were first announced a year ago following the review of the Japanese fusion program.

But in the last year, the U.S. fusion effort, which was the pacing program for the rest of the worldwide effort, has shifted gears. Under the influence of President Reagan's Science Advisor, Dr. George Keyworth, and economic advisers such as Office of Management and Budget head David Stockman, national policy for fusion research has been put on a 70-year timetable for commercialization and is in the process of being reoriented to a "pure research" program.

It is clear from presentations made in the first two weeks of September at the fusion meeting of the International Atomic Energy Agency in Baltimore and in a workshop before Congress on Sept. 8, that the European and Japanese fusion programs are outpacing the U.S. effort. If this occurs, it will be the first time in modern history that an advanced industrial nation has thrown away its lead in a crucial science and technology field for the sake of quack economic theories, when there were no scientific or technological obstacles to continued research.

Japan: number one?

A decade ago, Japan barely had a magnetic fusion research program. In 1975 the government decided that the need to develop fusion as an energy source and the challenge to science and industry represented by fusion research qualified fusion as a "national program." The Japanese fusion research budget has increased 40-fold since 1973.

In March 1981, Japan's Nuclear Fusion Council, led by Dr. Shigeru Mori, decided on an aggressive development schedule for fusion which laid out an early 1990s goal to demonstrate engineering feasibility. In talks over the past two weeks, Dr. Mori and other representatives from Japan have explained that their program objectives were to develop fusion energy for Japan and to "establish a high-technology-based country."

According to Dr. Mori, this entails "concentrated investment in frontier technology research and development." Fusion, he said, is a "driving force and a suitable target for high technology" development.

The June 1982 long-range plan of Japan's Atomic Energy Commission pledges to "vigorously advance fusion energy development," a task which includes the construction of a Fusion Experimental Reactor (FER) to achieve self-ignition and engineering feasibility by the mid-1990s, along with alternate, non-tokamak fusion devices. As outlined at the IAEA meeting, the FER combines tokamak characteristics which, until 1980, Japanese scientists thought would be demonstrated in two separate devices—ignition of the fusion fuel, and engineering demonstration. Now they have decided to do both in the one machine, the FER.

The new plan calls for the construction of a demonstration reactor at the beginning of the next century, based on the results obtained from the FER. After that, magnetic fusion in

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Japan will be ready for commercial introduction into the elecrical-generating sector.

Japanese industry is already involved in fusion, another contrast to the United States. Almost all fusion experiments now on line were built not by scientists in laboratories, but by large industrial concerns. Japanese industry, therefore, is already building up years of experience and a highly skilled personnel pool which will give Japan a head start on building commercial fusion power plants over the next 20 to 30 years.

Japan's fusion program is not only running ahead of the United States in terms of the time scale for demonstrating technology, but Dr. Mori reported in his statement to Congress that only 30 percent of Japan's energy use is now electric. Though that will undoubtedly increase, he stated, producing synthetic fuels using fusion energy is a main objective of the Japanese program. The U.S. fusion program has been hamstrung financially and has not been able to allocate significant funding to demonstrate hydrogen and other synthetic fuel production from fusion, though the use of this technology to replace finite fossil fuel resources may well be the most important near-term application of fusion energy.

Japanese representatives reported at the IAEA meeting that designs for the FER are proceeding. Three possible devices, all tokamaks, are being considered. The most interesting is the proposal to put the entire fusion power machine under water—the "swimming-pool reactor" design. The water surrounding the tokamak acts as a shield against the neutrons streaming out from the nuclear reaction, and, as Dr. Mori remarked, "this is much easier to move out of the way than concrete" when the machine needs to be repaired or modified.

The Japanese are planning a multi-faceted program to develop the technology needed for the fusion subsystems. This includes various ways of heating the plasma fuel in the tokamak, through neutral beam, radio frequency power, or other methods. It also includes cooperative technology upgrades on the Doublet experiment at General Atomic Company in California.

Japan is also planning technology programs to develop large-scale superconducting magnets which are needed to confine the plasma, research into methods of handling radioactive tritium fuel, and materials research to develop materials capable of withstanding the severe conditions of fusion reactions. Up until the U.S. budget crunch of the past 18 months, Japan had been cooperating with the United States in most of these technology fields. Now they are wondering out loud whether they will have to pursue some of this work alone.

Europe close behind

Dr. Donato Palumbo, fusion director for the Commission of European Communities, reported to the congressional fusion workship in Washington that the Euratom fusion program was following a five-year plan, approved by the member-states' ministers. The program is operating at guaranteed funding levels, said Dr. Palumbo.

After preliminary results are in from the JET [Joint European Torus] under construction, the Europeans will make a decision on the Next European Torus (NET) machine. In the meantime, teams of scientists are working on conceptual designs for the NET, which they expect will be completed at the end of 1984. Dr. Palumbo said that construction on NET could start at the end of this decade.

At this time, the European effort is just a little under the U.S. budget of $450 million—about $400 million for this year. The cost of the 20-year effort they expect will lead to a demonstration reactor, will require about $20 billion over the next 20 years. "This would require tripling the yearly expenditures of each of the large programs'" in the European laboratories, Palumbo explained.

The Europeans, even more than the Japanese, have relied on the successes of the U.S. program to garner support for their effort. With budget difficulties in a number of European nations, as well as the United States, they are trying to formulate joint projects that can be cooperatively managed with the United States and Japan. Dr. Palumbo revealed that discussions were held at the IAEA meeting which might produce a joint machine for the reversed field pinch fusion geometry, involving the team of scientists at the U.S. Los Alamos Laboratory. Also, the fusion ignition experiment Zephyr which had been planned for construction in West Germany but was cancelled due to budget constraints, is being redesigned and may be a candidate for international cooperation.

In the area of materials development for fusion, the entire world effort has waited anxiously for the United States to build the Fusion Materials Irradiation Test facility in Washington state, but this facility has been zeroed out of the budget for the past year. Until about a year ago, the Europeans maintained a policy of encouraging the United States to build the FMIT. Now, reported Palumbo, the Europeans and Japanese are considering financial participation in building their own materials experiment.

The effect of U.S. fusion policy on the worldwide research program was evident in presentations from visiting scientists and administrators at the two meetings. Both the Japanese and Europeans are resolved to go ahead with this technology and bring it to commercial realization. They will do this, perhaps in closer coordination, even if the U.S. program continues to stand still.

All parties concerned recognize that the entire world effort will suffer without the participation of the facilities, scientists, and engineers of the United States. Nevertheless the Europeans and Japanese are strengthening their resolve to push ahead in this crucial area without the United States if they must, and are seeking to increase international cooperation to take the shortest path to commercial fusion development.