The World Needs The U.S. Fusion Program

by Marsha Freeman

Dec. 12—Each year's gathering of the leaders of many of the world's fusion programs in Washington, under the sponsorship of Fusion Power Associates, presents an opportunity to review the past year's progress in fusion, and discuss plans for the future. This year, there were two main themes of the two-day meeting: Asian nations are moving ahead with their plans to develop fusion as an energy source as quickly as they can; and the creative ideas and the decades of experience of U.S. scientists, and engineering and industrial capabilities, which are now under threat, are critical for these international programs to move forward.

The view of the Obama Administration toward fusion has been expressed directly by the President himself: we don't need any "fancy fusion" to solve our energy problems. Every other nation in the world thinks otherwise. The Congress cannot agree on what the American pathway to fusion should be, and to what level it should be funded. The world's premier scientists and their experiments in the U.S. hang in limbo, while the rest of the world moves ahead.

The U.S., Russia, Europe, Japan, China, India, and South Korea joined together in 2007 to build the International Thermonuclear Experimental Reactor (ITER) located in France, to combine resources, and demonstrate the feasibility of the production of fusion energy using the approach of magnetic confinement. At the same time, each ITER partner has its own domestic fusion energy program, which includes experiments on machines with other approaches to magnetic fusion beside the tokamak design of ITER, and which creates the scientists and engineers of the next generation.

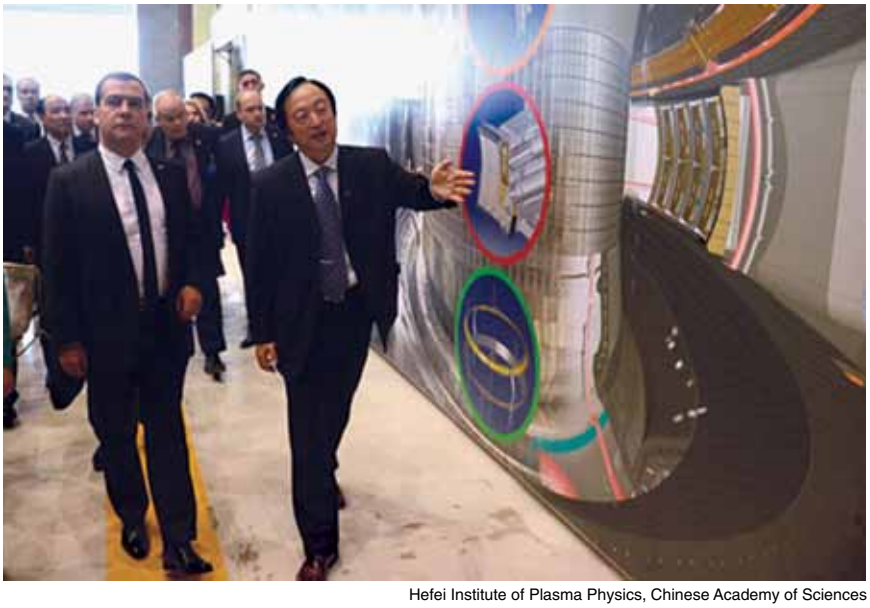
The Obama Administration's current proposal for magnetic fusion is to contribute to the American financial commitment to ITER (capped at $250 million per year, which is less funding than is needed), by cutting the domestic experimental programs by 21%. This proposed drop from $296 million to $233 million, will shut down facilities, lead to the firing of scientists, engineers, and students, and destroy the 50-year position of leadership that the U.S. fusion community has earned. The advice of the U.S. government to the fusion community? Move to Asia, and do experiments there! Not even the nations which would appear to "benefit" from such a proposal in any way support shutting down the U.S. fusion program.

A Worldwide Effort

Since the first round of declassification of Soviet and U.S. thermonuclear fusion research during the 1950s, this has been an international endeavor, with the sharing of ideas, data, personnel, and experimental machines. The quintessential example of this collaboration is the ITER program.

At the FPA meeting, out of a sense of despair over the U.S. situation, some scientists put forward the proposal that the U.S. participation in ITER be cancelled, and that those "saved" funds be redirected back into the domestic programs which have been cut. Wiser participants noted that that money will never be put back into fusion, if the U.S. backs out of ITER.

ITER has come under intense criticism for being years behind schedule and billions of dollars over budget. However, there was no mention at the meeting that the International Space Station, which, all told, cost the United States about $100 billion, also was years behind schedule, and tens of billions of dollars over budget. Any international engineering project of the size and complexity of either the space station or ITER, which is at the leading edge of known capabilities, will incur delays and missteps. This is not unique to this



Hefei Institute of Plasma Physics, Chinese Academy of Sciences

International cooperation has been a hallmark of fusion research from the beginning. Prof. Jiangang Li (right), director of ASIPP, gives Russian Prime Minister Dmitri Medvedev a tour of the Institute, Oct. 23. Academician E. Velikov, president of the Kurchatov Institue (walking behind them), is the originator of the concept that became ITER.

project, and should have, by all accounts, been expected.

The progress being made at ITER is impressive, and director general Osamu Motojima showed both the construction at the site in France, and the progress being made by each ITER partner in engineering and fabricating the myriad unique components. However, he reported that the plasma fusion experiments have been postponed from 2020 to 2023, and there is now an effort to see what can be done to recover some of the schedule, and stop schedule "seepage." By the end of 2014, the major tokamak components will be arriving at the site to begin assembly.

But Dr. Motojima also stressed, more than once during the two days, the importance of the role of the U.S. in the success of ITER. He also said that other countries have shown an interest in joining the project, including Australia and Brazil.

Trying to counter the proposal to end U.S. participation in ITER, Ned Sauthoff, head of the U.S. ITER Project, refuted "rumors" that the "costs are out of control," and explained that the escalation in the U.S. portion of the contribution to ITER has, in fact, been from $1.3 billion to $1.55 billion. The budget is capped at $225 million per year and at that level it will take longer to complete the U.S. contribution, adding to the total cost, he explained. In answer to a question, he said that if the annual amount were raised to $300 million, the work would be done in seven rather than ten years, and save a half billion dollars, overall. Dr. Motojima concurred that the worst-case estimates are too high.

During the 1970s, when U.S. fusion funding allowed a stream of breakthroughs in new regimes for creating fusion energy, the next-step experimental machines were being designed at the same time that results from the operating experiments were still coming in. Today, the U.S. has no approved plan to start on any new device. It is China and South Korea that are the leading examples of this parallel approach, because they have made national commitments to create a fusion economy.

Beyond ITER

Dr. G.S. Lee, who earlier led the KSTAR project at the National Fusion Research Institute in South Korea, presented his nation's plans for a demonstration fusion tokamak which will build upon work on ITER and Korea's superconducting tokamak, KSTAR. The next step K-DEMO, or Korea Demonstration project, already has a project office in operation at the Institute, now led by Dr. Lee, with design work underway. If you wait until the results are all in from ITER to start the next step, Dr. Lee explained, it would be 20 years between machines, which is an entire generation of fusion scientists, and is too long.

The purpose of K-DEMO is to move from the demonstration of a burning fusion plasma in ITER, to a demonstration of the production of electricity that is the basis for a commercial power plant. It will be designed to produce on the order of 400MW of net electric power.

At the current time, the K-DEMO designers are creating options to be presented to the government for approval. Between now and 2021, the core technology development for the design of K-DEMO will be carried out. By 2028, the final design will be decided, and construction on the next machine will begin. The ma-

ITER Organization

The International Thermonuclear Experimental Reactor, ITER, is under construction in Cadarache, France. Next year, the largest components for the machine will start to arrive on site from around the world.

chine will operate through 2036. At that time, construction of a commercial fusion power reactor will begin.

Dr. Lee reported that the current funding for the Korean fusion program is about $250 million per year, with about $100 million of that for Korea's work on ITER. The Institute has requested an additional $700 million over the next eight years, to carry out the R&D for K-DEMO. But while presenting a visionary path for the domestic Korean fusion program, Dr. Lee made the startling statement that "If we had to, we would stop KSTAR for ITER; we would do that. The most important project now is ITER," he stated uniquivocably.

Cognizant and appreciative of the expertise and experience in fusion in the U.S., where Dr. Lee worked in the past, South Korea's National Fusion Research Institute signed an agreement with the Princeton Plasma Physics Laboratory in January to cooperate in the design of Korea's K-DEMO reactor. Korean scientists will gain access to Princeton's decades of experience in designing and engineering fusion test facilities, and the American scientists will have access to one of the world's most advanced tokamaks.

Like South Korea, China has an advanced magnetic fusion program, centered on its EAST (Experimental Advanced Superconducting Tokamak) machine, which is at the Institute of Plasma Physics, in Hefei. Academician Yuanxi Wan, who headed the Institute, and now works closely with the team of young Chinese scientists at ITER, presented China's next step beyond ITER, which, he said, is "strongly supported by the government." China's fusion budget is about $350 million, involving 20 institutes and universities in 66 projects, he reported. "The key is to support ITER as a success first, then, a Chinese reactor."

Dr. Wan explained that China plans to enhance

its domestic fusion research, by upgrading its EAST tokamak, stressing education and recruitment of young scientsts, and working on key technology challenges.

China is proposing that its next-step machine be the Chinese Fusion Engineering Test Reactor (CFETR), which would be a complement to ITER. One focus will be the development of new materials that are suitable for fusion reactor conditions.

The working schedule for CFETR is to present two options for its design to the government by next year, and start work in 2015 on R&D. Between 2030 and 2040, research will be carried out on CFETR and also on a planned demonstration reactor, leading to a fusion power plant by 2050.

National Fusion Research Institute

Educating the next generation: Students from the Daegu Jung-ang Primary School visited the South Korean KSTAR tokamak experiment in 2010.

China has also actively engaged in bilateral agreements with international partners. In July, a cooperative agreement between EAST and Europe's Tore Supra (renamed, "WEST"), was initiated. In September, an agreement was signed with Culham Laboratory in England, home of the Joint European Torus. In October, to improve cooperation, Russian Prime Minister Dmitri Medvedev visited EAST, along with Academician E.P. Velikhov, the initiator in the 1980s of what became ITER.

Recently, Chinese EAST scientists joined American colleagues in San Diego, for research using General Atomic's Doublet III tokamak. The Chinese scientists were interested in duplicating and verifying EAST's results on a second machine.

One scientist knowledgeable about the cooperation, reported that the Chinese are not only paying the travel and expenses of the scientists they send, but also for the time on the DIII machine, and some of the expense for American scientists who travel to China. This support helps to make up for budget cuts to the U.S. fusion program.

Hiroshi Horiike, from Osaka University, reported at the meeting on Japan's plan for fusion research after completion of its JT-60SA, superconducting tokamak. The Japanese have a DEMO design center; and their timeline is to do R&D until 2025, and then build a DEMO between 2025 and 2040. It would focus work on the areas that are not being covered in ITER.

Francesco Romanelli, representing the fusion programs of the European Union, described the Horizon 2020 program, which has a goal of fusion by 2050. DEMO construction would start in 2030, but Romanelli made clear that, "The success of ITER comes first." A decision on constructing a DEMO will be made in 2030. European scientists are working with Japan on designs. The budget the fusion programs are requesting

is for EU758 million for five years, not including the fund for ITER, he reported.

Fight for What Is Necessary

Fusion research in the United States is at a crossroads. The MIT Alcator tokamak is shuttered in a "warm shutdown." It can be ready to re-start if the funding ever materializes. But Alcator has supported the research of 30 students. If things do not change, the estimate is that in a year, there will be five students left, and the most experienced faculty will continue to retire.

Graduate students have already started to look for work elsewhere, reports Dylan Brennan, president of the University Fusion Association. At this rate, he advises, there will be no next generation of fusion scientists; at least, not in the U.S.

The Department of Energy, which knows fusion is "not a priority" for this administration, has tried to encourage scientists to "go east, young man." As Amanda Hubbard, representing the U.S. Burning Plasma Organization of scientists, put it, you have a choice, "to leave fusion or leave the country."

The other main approach to fusion, inertial confinement, has fared no better in terms of government support. As punishment for not meeting announced goals, the world-class National Ignition Facility at Lawrence Livermore Laboratory will not be supported for fusion energy research, but entirely directed to the weapons research it carries out.

For many years, the contraction in the budget has eliminated support for the wide range of possible approaches to achieving fusion, in both magnetic and inertial confinement approaches. Research in some non-tokamak magnetically confined "alternate concepts" has been carried out in other countries, and is being pursued by private companies here. But the rich heritage of a broad-based fusion program has been largely squandered in the U.S.

If the U.S. fusion community compromises now, either pitting ITER or other projects against each other, or falling for the age-old trap of, "you tell us what we should cut, so at least you are making the decisions," we will have no U.S. fusion program.

The only effective approach is to fight not for what is possible, but what is necessary.