Previewing the next steps on the path to a magnetic fusion power plant

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Scientists around the world have crossed a threshold into a promising and challenging new era in the quest for fusion energy. So says physicist George "Hutch" Neilson, director of advanced projects at the U.S. Department of Energy's Princeton Plasma Physics Laboratory, in remarks prepared for the 2013 annual meeting of the American Association for the Advancement of Science in Boston.

The new phase has begun with the construction of ITER, a fusion facility of unprecedented size and power that the European Union, the United States and five other countries are building in France. Plans call for ITER to produce 500 million watts of fusion power for some 300 second during the 2020s. With construction of ITER under way, many national fusion programs "are embarking on their own projects to demonstrate the production of electricity from fusion energy," Neilson said.

These nations are considering "DEMO" programs that would mark the final step before the construction of commercial fusion facilities by midcentury. Such programs have brought worldwide researchers together to discuss common challenges in annual workshops that the International Atomic Energy Agency began sponsoring last year. "The scientific and technical issues for fusion are well known," said Neilson, "but the search for solutions is extremely challenging."

The key issues:

- Development of computer codes to guide the design of DEMO

plants.
- Development of material for the interior of the plants.
- Methods for extracting fusion power.
- Methods for handling the exhaust from fusion reactions.
- Requirements for devices to develop DEMO components.

Individual countries are exploring their own paths to a DEMO, based on their perceived need for such energy. All such plans remain tentative and subject to government approval.

A look at the possible roadmaps that countries are considering:

- China—The world's most populous nation is pushing ahead with plans for a device called China's Fusion Engineering Test Reactor (CFETR) that would develop the technology for a demonstration fusion power plant. Construction of the CFETR could start around 2020 and be followed by operation of a DEMO in the 2030s.
- Europe and Japan—These programs are jointly building a powerful tokamak called JT-60SA in Naka, Japan, as a complement to ITER. Plans call for construction to be completed in 2019. The Japanese and Europeans will then pursue similar but independent timelines. Both could start engineering design work on a DEMO around 2030, following the achievement of ITER milestones, and placing the DEMO in operation in the 2030s.
- India—The country could begin building a device called SST-2 to develop components for a DEMO around 2027. India could start construction of a DEMO in 2037.
- Korea—The program plans to build a machine that it calls K-DEMO that would develop components in the first phase, called K-DEMO-1, and utilize the components in the second phase, or K-DEMO 2. Construction could commence in the mid-to-late 2020s, with operations starting in the mid-2030s.

- Russia—The country plans to develop a fusion neutron source (FNS), a facility that would produce neutrons, the chief form of energy created by fusion reactions, in preparation for a DEMO. The FNS project is part of a Russian commercial development strategy that runs to 2050.
- United States—A next-step Fusion Nuclear Science Facility (FNSF) is under consideration. It would be used to investigate materials properties under fusion conditions, and develop components for a DEMO. Construction of the FNSF could start in the 2020s.

Provided by Princeton Plasma Physics Laboratory