



## FUSION RESEARCH

## Design Changes Will Increase ITER Reactor's Cost

The €10 billion ITER fusion project hopes to demonstrate that a burning plasma can be controlled to produce useful energy. This month, ITER's funders face their own daunting task of keeping the project's budget under control, as scientists present a wish list of design changes.

The changes are needed, say the researchers, because of advances in fusion science since the baseline reactor design was published in 2001. Although the wish list won't be publicly revealed until ITER's governing council meets in Japan on 17–18 June, insiders say the design tweaks are going to require more money, a fact that will not go down well with governments funding the project. "Where the pain level is for each [ITER] member is impossible to say," says David Campbell, assistant head of ITER's department of fusion science and technology.

The design review is not the council's only headache. The prices for steel and copper have skyrocketed this decade, and at the end of last year, the U.S. Congress zeroed out the country's ITER contribution from the 2008 budget. "The June council will be a key meeting," says Campbell.

ITER, or International Thermonuclear Experimental Reactor, has been on the drawing board since the mid-1980s. In 2001, the "final" design was ready, and, after much wrangling over the site, the governments of China, the European Union, Japan, Russia, South Korea, and the United States agreed to build it at Cadarache in southern France (*Science*, 1 July 2005, p. 28). (India joined the effort in 2006.) But before construction starts this year, ITER managers decided to ask researchers to review whether the design

could be improved to give the project the best chance of meeting its goals (*Science*, 13 October 2006, p. 238).

Led by Günter Janeschitz of Germany's Karlsruhe research center and completed late last year, the redesign report is said to recommend 80 modifications, including changes to the plasma's microwave heating system, the complex arrangements of magnets to hold the plasma in place, and the divertor, a device around the bottom of the doughnut-shaped vessel that extracts spent fuel. ITER staff and the Science and Technology Advisory Committee—a panel of fusion experts appointed by ITER members—have been poring over the report, trying to separate out the essential from the merely desirable, and estimating how much the changes will cost and their impact on the construction schedule. "All of these things cost money, ... [so] we must be careful not to make a list so long that the bill shocks everyone," says a senior European fusion researcher who asked not to be named.

One of the most contentious recommendations concerns a system to control explosive releases of energy at the edges of the plasma called edge-localized modes (ELMs). If they are too large, ELMs can erode the wall of the reactor vessel and damage the divertor. The current ITER design already contains a system to control ELMs: rapidly firing a stream of frozen deuterium pellets into the plasma, each of which causes a mini-ELM that does no damage. But researchers using the DIII-D fusion reactor in San Diego, California, discovered another way: A weak magnetic field can make the edge of the plasma slightly leaky and take the sting out of ELMs.

Such a system would be simpler and more efficient than pellet injection, but to create the

magnetic field requires adding electromagnetic coils inside the reactor vessel—a major and expensive design change. Some think it's too soon to decide on such a major modification. "It's clear the field has an effect. But we don't yet understand the physics. It'll take 3 to 4 years to nail it down," says Hartmut Zohm of the Max Planck Institute for Plasma Physics in Garching, Germany. Zohm and others suggest that a redesign could make space for the coils with the decision to install them taken later.

ITER council members will also be eager to hear about the U.S. budget situation. The decision by Congress last December to remove the \$149 million ITER funding from the fiscal year 2008 budget was considered unfortunate but not catastrophic by ITER insiders. "In 2009, we'll be ready to get running," says Ned Sauthoff, head of the U.S. ITER effort, adding: "We're a family. We'll figure out how to get through this." Last month, the U.S. Senate approved spending \$55 million on ITER this year as part of a bill now before Congress to fund the military in Iraq and Afghanistan. The bill's fate is uncertain, however, as the Bush Administration opposes any additional domestic spending.

The talk in Washington is that, with a presidential election looming, Congress will simply extend the current budget for another 6 months, leaving ITER out in the cold until April 2009. This could prompt some ITER members to query the United States's commitment to the project. Says ITER project construction leader Norbert Holtkamp: "If the U.S. doesn't restore funding in 2009, then we have a very tricky problem. We have to ensure that 2009 is okay."

—DANIEL CLERY



**Making space.** Construction workers clear the ground for ITER at Cadarache.

CREDIT: AGENCE ITER FRANCE