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Cost increases at fusion project going critical

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For Lewis, liquid fuels from hydrogen should be considered a long-term goal for JCAP. "It's very clear that the first fuel we're going to produce is [hydrogen] from water splitting," he says. That hydrogen might be used to upgrade biofuels to higher energy content or to reduce CO_2 to make synthetic fuels. The choice of fuel could be left to the chemical and refining industries, which know how to convert one fuel to another with minimal energy loss, he notes.

What's ahead

Looking ahead five years, Rothschild sees efficient, functioning AP arrays of perhaps 1 m^2. Those will need to be tested over thousands of hours for durability and energy conversion efficiency, he says. Life-cycle analyses will indicate whether AP could produce hydrogen at a competitive cost, which Rothschild estimates is around $3/kg in the US and €5/kg ($6.70/kg) in Europe.

"This technology has only been demonstrated in the lab; it's very difficult to make projections of how it will work in the field over many years," Rothschild says. AP also could provide a solution to the grid-leveling challenge that increasing PV electricity generation will present; using combined water splitting and PV arrays would produce a clean-burning fuel for nighttime power generation. He cautions that AP will have its environmental impacts. "It's clear that this is not zero emission, because at a minimum you should count the CO_2 you use in making the devices. You also need to think about how much water we need and where we'll get it."

Frei and Lewis say they expect JCAP to have a working prototype by 2015, when the center's five-year contract is up for renewal. To make a device with the targeted 5–10% efficiency could take another five years. Hagfeldt agrees that 10 years is a reasonable estimate for having AP technology in practical use. "It's very important that you keep several options open. Whether you go for electricity or for fuels from solar energy is complementary. It's not an either–or; you need both."

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Cost increases at fusion project going critical

US domestic program braces for budget cut as senators seek schedule for completion and cost of ITER.

How much will it cost to build what could well be the first machine to achieve a self-sustaining nuclear fusion reaction? Apparently no one really knows, and that information vacuum hasn't been sitting well with some influential US lawmakers.

Construction of the international prototype fusion reactor is under way at Cadarache in southern France, but the project is proceeding without a formal cost baseline. In May, four senators who hold the purse strings for the US contribution to ITER ordered an investigation into ITER's cost; they asked the Government Accountability Office to figure out how much the project will cost and what the US will have to pay.

During a hearing of the Appropriations Committee's energy and water development subcommittee, which she chairs, Senator Dianne Feinstein (D-CA) asserted that the US share of ITER will reach $3 billion. The Department of Energy's fiscal year 2014 budget request, released in April, put the value of the US contribution at $2.4 billion but described that as a "subset of our obligations" that continue through to ITER's achieving its first experimental plasma. Originally set by the project collaborators for 2016, the first plasma date has been pushed back several times and now officially stands at 2020.

Feinstein said that "ITER has no cost, schedule, or scope baseline, and there is no way to evaluate how much it will cost or its impact on the domestic [fusion research] program and over what time frame. The lack of information is unacceptable. Congress can't evaluate the cost without a project baseline." Feinstein said she'd been told by DOE to expect the date for first plasma to slip to 2023.

The budget request from DOE for FY 2014 includes $225 million for the US ITER contribution, more than double the $105 million appropriated in FY 2012. The US domestic fusion energy research program is being asked to pay for part of the ITER contribution; the budget request would provide the US program with $233 million, down from $288 million in FY 2012. The cutback would include closure of MIT's Alcator C-Mod, one of three US experimental tokamak reactors.

MATTHIEUCOLIN.COM/ITER ORGANIZATION

An aerial photo of the ITER complex under construction in Cadarache, France, in February 2013.

A currency-free cap

Although a cap on ITER's budget has been in place since 2010, it's expressed only in credits known as "ITER units of account." The best guess, project officials say, is that ITER will cost €13 billion (about $16.8 billion). That's based on an extrapolation of what the European Union (EU) estimates it will cost its member states to build their share of the project's components. But the actual costs will vary from country to country depending on individual industrial fabrication costs. As host, the EU is contributing 45% of ITER; the other six countries—Japan, Russia, South

Korea, China, India, and the US—will give 9.1% each. "Basically, the US is building a certain number of components for ITER as part of the agreement; the same is true for Europe, except they have to build five times more," says Richard Hawryluk, who just returned to the Princeton Plasma Physics Laboratory after serving for two years as ITER's deputy director general for administration.

The ambiguity decried by Feinstein dates to the unique international framework that the seven ITER parties established when the project got under way in 2006. At the time, ITER was estimated at $5 billion.

Some cost growth is perhaps unavoidable with such an ambitious project. "We've got new nuclear power stations in Europe that are two, two and a half times over budget, about the same level as ITER," says Steven Cowley, director of the UK's Culham Centre for Fusion Energy. "But consider that nuclear power is a known technology, and ITER is stepping out into the unknown."

Current and former ITER officials see a number of factors behind the ballooning price tag. For one, ITER was structured as a true partnership, unlike most big science projects in which one party acts as the lead. A central ITER Organization (IO) had to be created in France, and the partnering countries each set up offices known as domestic agencies to design and procure their share of ITER's components. Says Hawryluk, "If you go to the site, you'll see buildings being built. You can see components being built around the world. The superconducting strand for the coils is nearly complete. The huge undertaking around the world in support of this project is really coming together. But being a brand new entity, it's taken a while to get to this stage."

Optimism and accounting

The original estimate also was based on incomplete and immature designs, says Hawryluk. "The fundamental requirements of the machine have not changed for several years. However, the level of detail of the design has been evolving. This is absolutely normal; you start off with a conceptual design for a project, then you go to preliminary design, and the final design."

In 2002, before the US rejoined ITER—from which it had withdrawn in 1998—a review by DOE's Office of Science found the then $5 billion estimate to be "supported by the design and R&D results that are unusually mature for a science project facing the decision to fund construction."

At the time the agreement to build ITER was signed in 2006, costs had been estimated "in a very optimistic way," says Rem Haange, an IO deputy general. For example, skilled labor rates in Canada, which were then quite low relative to those of other nations, were used because Canada had been bidding to host the project. And prices for commodities like stainless steel and nickel-based alloys have gone up considerably over the years. To a large extent, ITER's cost was estimated by halving a $10 billion version of the ITER reactor that the partners had rejected as too costly. But in reality, he says, costs didn't scale down in direct proportion to the size of the machine.

Haange says the IO has now issued the final requirements, known as procurement packages, covering 82% of ITER's components. The packages allow the domestic agencies to solicit bids to build the items. But the central office isn't necessarily done with the process: "Industry wants to make things the cheapest possible way, so they have many requests for changes. These have to be checked again by our designers to see whether it's acceptable," Haange says.

Once a component—say, a magnet—has been accepted at the ITER site, the IO applies a set number of credits toward the party's contribution. But for any given item, China or India would receive the same number of credits as the US or a European nation, even though China's or India's procurement costs could be one-half to one-third the costs in the US or Europe.

Deliberate duplication

Another ITER feature is blamed for cost growth. When the parties determined who would contribute what to the project, each looked to get a piece of the high-tech componentry. "Instead of being given to one party, they have been carved up into little bits so that every member could qualify their industries for these particular challenges," says Haange. In what Hawryluk described as "the biggest procurement of its type ever conducted in the history of mankind," 750 tons of niobium–tin superconductor for ITER's magnets was divvied up among six of the seven parties to make. "The parties said we know we're not going to be efficient doing this, but nonetheless, for the development of our scientific or industrial base, we want to develop those components," says Hawryluk. "They chose to do that, but they are doing it at their own expense. That's what makes cost associated with ITER a lot trickier than with a normal project."

Haange says new management processes and procedures have been implemented to minimize further schedule slippages and cost growth. The IO, which is responsible for procuring the massive cryogenic plant and some other items, has been operating under a capped budget for several years. Last year a new group called the "unique ITER team" was established to connect top officials at Cadarache with the heads of the domestic agencies.

If the US were to leave ITER, the project would likely survive; but no one involved wants to see that. "On paper, ITER without the US could succeed, with quite a bit of delay and impact," says Hawryluk. "We have a lot of key technology, experience to bring to the party, and we really make an impact. I think in the scientific areas, we probably do more than our 9% contribution."

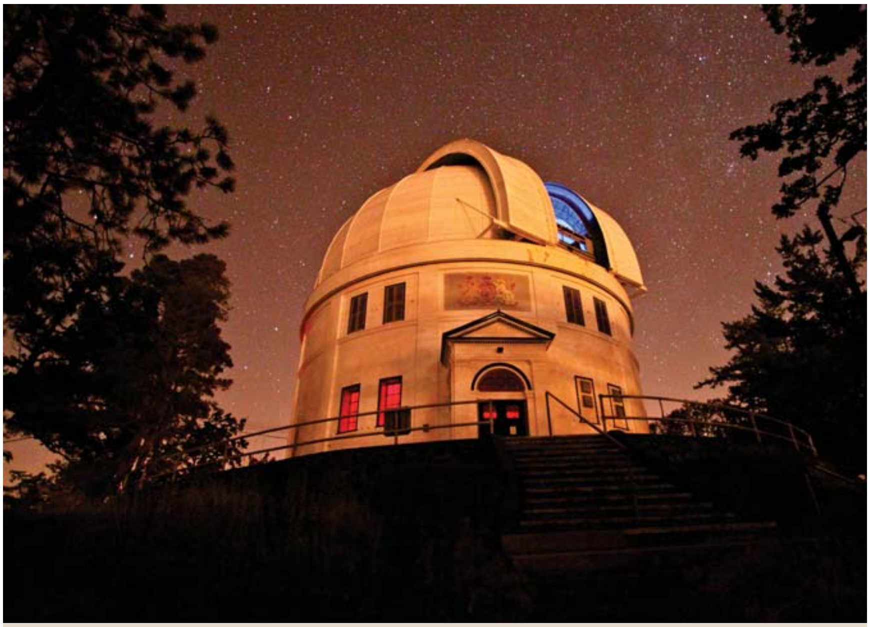
"Is it possible to [build ITER]? Yes it is; piece by piece it's happening," says Cowley. "I'm convinced we can build ITER now, but we've got to be patient." He observes that the US "tends to like international projects where it has a major role, and for ITER it doesn't have a major role." But he adds, "to the rest of us ITER partners, the US is critical, because some of the best science and engineering goes on in the US."

David Kramer

Business emphasis at research council has Canada's scientists concerned

In bolstering industry, the NRC aims for innovation and economic gain. Will isolation from research developments also result?

Canada is restructuring its National Research Council, which does in-house scientific research, funds external projects, and provides services to industry, to focus mainly on industry. The move is motivated by a wide recognition that Canada lags other countries in innovation, according to NRC president John McDougall. "We want to fill the gaps between discovery and things in the marketplace." But researchers worry about the repercussions of what they see as yet another in a series of slaps the government has dealt science (see PHYSICS TODAY, July 2012, page 20).



NATIONAL RESEARCH COUNCIL OF CANADA

Many scientists are asking if the future is safe for basic science—such as this telescope at the Dominion National Observatory in Victoria, British Columbia—at the National Research Council of Canada.

Unveiled on 7 May, the new structure of the NRC has been in the making since the release nearly two years ago of the government-commissioned report *Innovation Canada: A Call to Action*, which said Canada should identify strategic areas, streamline its interactions with companies, and focus more on commercialization. The NRC response includes a reorganization from 21 independent institutes into 12 R&D portfolios falling into the three categories of engineering, emerging technologies, and life sciences. In the process, the NRC has shed at least two institutes: A medical diagnostics center in Manitoba was closed, and in April the Canadian Neutron Beam Centre was transferred to Atomic Energy of Canada. "This refocused NRC, with a business-led innovation mission, is pivotal to the future of Canadian jobs, economic growth, and our long-term prosperity," said Gary Goodyear, minister of state for science and technology.

Tools for industry

A key feature of the refocused NRC will be large industrial R&D projects. The first one, announced on 10 May, will explore using algae to convert carbon dioxide emissions from Alberta's oil