1. Catallaxy Files

*Australia's leading libertarian and centre-right blog*

**Requiem for a failed electricity system**

*Posted on 6:06 pm, October 6, 2016 by Alan Moran*

**The trouble with wind**  South Australia has on average over 40 per cent of its internally generated electricity derived from wind. This is one of the highest levels in the world for a load with a relatively small interconnection with other sources (the two interconnectors with Victoria have a capacity to supply about 20 per cent of the state’s needs).

Wind/solar generation has two features that are of concern. The first is that it is intrinsically high cost. As a mature technology, it will remain three times the cost of coal powered generation in Australia. It can only compete because it is subsidised by a regulatory charge on the consumer (thereby also not facing the same scrutiny if its support was through the Budget). It receives the subsidy whenever it runs, hence wind has an incentive to generate whenever it can, forcing established fossil fuel plant to be placed offline.

Wind’s additional capacity depresses prices in the short term. Because most of the costs of existing fossil fuel plant are sunk, they will continue to operate. But once major repairs are necessary the established coal plant is scrapped.

Gradually the electricity price will rise to reflect the higher cost wind generation that is being substituted for the non-subsidised supplies. But this rise is muted as the higher prices will cause high energy intensive industries to close, reducing demand. Already we have seen the Point Henry aluminium smelter close and the Kurri-Kurri smelter mothballed. The same outlook appears imminent for the Portland smelter.

Secondly, wind/solar is inherently less manageable than fossil, nuclear or hydro-generation. It requires its fluctuating supply to be shadowed by counter fluctuations. This requires additional costs and careful management.

**South Australia’s electricity system breakdown**  The [preliminary report](#) of the Australian Energy Market Operator (AEMO) on the south Australian blackout was published October 5. It summarized the position as

*Generation initially rode through the (weather induced) faults, but .. 315 MW of wind generation (then) disconnected .. result(ing) in ... the Heywood Interconnector overloading,. tripping the interconnector. In*
this event, this resulted in the remaining customer load and electricity
generation in SA being lost (referred to as a Black System)
Actually the AEMO had already spilled the beans. In its Market Notices
system amidst some the 30 or so routine operating statements that
AEMO posts each day came Notice 516103 on 3 October. This not only
said the collapse in wind generation had caused the system to black-out
the whole state but went on to redefine nine wind farms as unreliable
generators. AEMO basically said that the event is not a one-off
contingency but that the cascading effect of a state wide South Australia
blackout as a result of losing some pylons was intrinsically likely to re-

This finding did not prevent the promoters of wind and other sources of
power from placing themselves in denial. Tony Wood of the Grattan
Institute wrote an article in the Australian headed, “Don’t blame
renewable energy for the state’s plunge into darkness”. Many other
apologists for the renewable industry were scathing about those like
Minister Frydenberg who suggested wind had played a part. And even
after the publication of AEMO’s report, the industry’s propaganda
journal, RenewEconomy, was claiming it “raises questions answers
none”.

Who’s to blame? AEMO itself as an entity is not immune from
criticism. On many occasions its engineers have said that operating a
system with high wind share is technically feasible.
In public has drawn attention to problems of integrating more wind but
expressed confidence in doing so and been hopeful that this would be
further facilitated by advances in battery storage technology. But, as
Brendan Pearson’s quote of the Chief Scientist Alan Finkel makes clear,
this is overly optimistic. The Chief Scientist estimated that “if we
retrieved all of the batteries made for use in mobile phones, laptops,
cars and industry in 2014 and used them as back-up for the electricity
system, we would have enough energy to power the world for just nine
seconds.”

And in its submission to the Senate in July of last year AEMO, while
expressing some concerns about high wind penetration in South
Australia, said

Based on experience to date and analysis of likely future outcomes,
AEMO considers that it is technically feasible to integrate the
renewable energy likely to emerge from the RET while maintaining the
security of the power system. In the longer term if even higher levels of
renewable generation eventuate, there is likely to be some additional
grid support costs to maintain system security and to meet frequency
standards. (Select Committee on Wind Turbines Submission 469)
The former head of AEMO Matt Zema (who, sadly, has since died, hence
his private counsel is no longer confidential) was less sanguine at least
in private. Mr Zema during the course of a private briefing in April of
this year the former head of AEMO, made the following comments
The renewable developments and increased political interference are
pushing the system towards a crisis. South Australia is most vulnerable with its potential for wind to supply 60 per cent of demand and then to cut back rapidly. The system is only manageable with robust interconnectors but these operate effectively only because there is abundant coal based generation in Victoria. Wind, being subsidised and having low marginal costs, depresses the spot price and once a major coal plant has a severe problem it will be closed. New coal plants cannot be built because governments are hostile and banks will not finance them. Wind does not provide the system security. But the politicians will not allow the appropriate price changes to permit profitable supply developments from other sources. In the end the system must collapse.

Mr Zema thought that once network collapses occurred, Ministers would search for a fall-guy and would plump for AEMO. In the light of the agency’s guarded public statements, AEMO may have cause to fear being accused of culpability in the collapse.

The political landscape on energy is littered with cant. It is conditioned by a public persuaded that global warming will bring untoward harm and that the costs of substituting wind and solar (both of which are depicted as fundamentally free) will be, at worst, trivial. This is powered by rent-seeking businesses, conventional energy suppliers included, which see a path to greater profit from investments which have their risks underwritten by governments to give assured returns. The PM and his colleagues energy minister Frydenberg, industry minister Hunt and South Australian frontbencher Christopher Pyne have been forthright in hitting their political opponents. In the main this has been because of inconsistency between state plans and incentives. The ALP remains a supercharged romantic wedded to a 50 per cent renewable target by 2030. But the Coalition has been little less supportive the patronage-rich renewable industry. Indeed, South Australian wind farms were built on the back of federal and not state subsidies and few demurred at their level until the earlier near miss blackout in July of this year.

In fact, the Coalition, while criticising the ALP’s goal of 50 per cent renewables by 2030 itself has a goal of 23.5 per cent renewable share by 2020. Given that hydro cannot be increased, this means it is looking for 15 per cent from wind and solar by 2020. That implies a massive and unachievable expansion from those sources’ present contribution of six per cent.

**Aftermath** Each state has reacted differently.

In Victoria energy minister D’Ambrosio is powering ahead with increased renewable programs and supplementing this with prioritising battery storage. This entails horrendous additional costs. But the state is passing down the same de-industrialisation path as South Australia and if wind expansion causes Hazelwood power station to close will be partly offset by mothballing the Portland smelter, hence immediate price effects will
be suppressed.
The South Australian government is shell-shocked at having moved from the frontier of a Brave New World to third world status and, for its part, Queensland is now saying its absurd 50 per cent renewable goal was just aspirational.
Energy Ministers are meeting tomorrow to engage in some mutual mud-slinging.

2. South Australian blackout:
When the lights go out, it's a sign the electricity grid isn't working well

**ANALYSIS**
By political editor Chris Uhlmann
Updated 6 Oct 2016, 5:40am


The blackout of an entire state is rare. And bad.
Having all the lights go out in a storm, even a big one, is not a sign of an electricity grid that's working well.
And the Australian Energy Market Operator's (AEMO) preliminary report has not yet determined why the whole of South Australia went to "black system" at 4.18pm local time on Wednesday September 28.
"The root cause is subject to further analysis being conducted," it says.
Once those statements would have seemed uncontroversial but not in the political storm that has raged since South Australia was shut down over a week ago.
Now to dare suggest that the state's heavy reliance on wind generation might have made its grid more vulnerable to a blackout is heresy.
So, since this column raised that heresy last week, let's examine it again, in the light of the AEMO's preliminary report on the event.
The starting point is to understand South Australia's unique energy mix. The state now gets 40 per cent of its power from wind — a higher proportion than most other places on earth — and all coal-fired generation has been mothballed. The rest comes from a mix of gas-fired power and two interconnectors that link it to Victoria's brown coal-fired power plants.

Wind presents two engineering problems when it is hooked up to a grid that was designed before it was viable. First, it is intermittent so all of it has to be backed up by baseload power for those days when the wind does not blow. Second, for an electricity network to function, demand and supply have to be kept near the perfect harmony of 50 cycles (50 hertz) every second of every day. If the frequency gets out of tune it trips the shutdown switch. This electrical harmony is called synchronous supply, and thermal power is very good at delivering it. Wind power is asynchronous as its frequency fluctuates with the breeze, so it has to be stabilised by the give and take of other sources of demand and supply.

To ensure a reliable supply of electricity at an acceptable standard AEMO has frequency ancillary control services in place to deal with rapid changes in the ebb and flow.

**Power operator knew storm was brewing**

The AEMO report says that the energy market operator was expecting "severe weather" on Wednesday September 28. Just before the power went down there was 800 megawatts of wind generation, 330MW of gas and 610MW was being imported from Victoria.

That wasn't the only thing being imported. The report says "there was no local [frequency ancillary control services] requirement pre-event, as there was no credible risk of separation of SA from the national electricity market." That seems an extraordinary statement. The operator knew a storm was brewing and took a punt that the line to Victoria would stay up, keeping South Australia's frequency in harmony.
If the gamble fails so will South Australia's capacity to control rapid changes in supply and demand and whatever power generation is left in the state will be snuffed out. The real drama plays out in a 90 second window between 4:16:46pm and 4:18:16pm. The weather triggers a series of transmission faults and three major 275 kilovolt lines are lost. Then, in two separate events, 315 MW of wind generation is disconnected. This unexplained, rapid loss of wind power is the event that begins the cascade towards blackout. "In the events leading up to the SA region black system, generation reduction occurred at six wind farms," the report says. "There was no reduction in thermal generation." Why it happened is still a mystery. "Additional analysis is required to determine the reasons for the reduction in generation and observed voltage levels before any conclusions can be drawn," the report says.

Demand then shifts dramatically to the line with Victoria. Just before the wind generation failed the Heywood interconnector's flow was about 525 MW, well within its normal operating limit of up to 600MW.

The reduction in generation and the oscillations caused by the transmission network events drove demand to "flows between 850 to 900 MW" well in excess of its capacity. So it shut itself down. Now the "non-credible" had become credible. At 4:18:15pm the door to Victoria slammed shut, draining 900MW of supply in a heartbeat. There was "a rapid reduction in the power system frequency" in South Australia and it "fell to zero". That tripped the two thermal power stations at Torrens Island and Ladbroke Grove and all remaining wind farms. And the lights went out across the state.

It should be noted here that the report says that 14 of the 22 transmission towers that went down did so, "following the SA black system".

System had further flaws
In the eerie dark that followed the operator immediately began working through a pre-determined restoration plan. And that revealed more deficiencies in the system.
The operator has two contracts in South Australia for System Restart Ancillary Services (SRAS). Their identities are a secret for contractual reasons, so the report calls them SRAS 1 and SRAS 2.
Plan A was to use SRAS1 to jump start the thermal power station at Torrens Island and, at the same time, restore the interconnection with Victoria.
"This was seen as the quickest and safest way to restore supply to South Australia," it says.
In a footnote it adds, "wind farms cannot be used in the initial stages of a power system restoration due to the variable nature of their output".
Things didn't go well.
"Due to an issue currently under investigation, SRAS provider 1 was unable to supply sufficient capacity to restart any of the Torrens Island power station units," the report says.
SRAS 2 was out due to "damage caused by the storm".
Plan C was to hook up the interconnector with Victoria and use it to jump-start the state. By 6:54pm Torrens Island was restarted but it needed another two hours before it could deliver any power.
At 6:36pm the operator was advised that the gas-fired turbines at Pelican Point could be ready in four hours. Here, it's worth noting that gas plants can't just spring into action — they need time to warm up. Pelican Point had been offline before the storm, bid out of the market by cheap, abundant wind.

SA power system 'extremely fragile'
So what have we learned from this report?
That weather sparked a series of events that spiralled into a state-wide blackout. That it was the sudden loss of wind power that tripped the interconnector with Victoria and that loss of generation is yet to be explained.
It is also undeniable that South Australia now has an extremely fragile power system. It cannot operate with any confidence if the interconnector with Victoria is down and if the state blacks out it can't be restarted with wind power.
Politicians have said a lot of things in the wake of this outage. But judge them by what they do.
South Australia is already calling for rule changes in the
national electricity market because it recognises its reliance on wind and rooftop solar has made the state's system less secure. This won't be the last fix that South Australia will need to patch up the problems. Finally, we know that the energy market is in transition to cleaner forms of power and that is unstoppable. In time the engineering difficulties posed by wind will be overcome. Or they will be as long as people aren't burned as heretics for daring to point out the real and well documented problems with integrating new forms of energy into an old grid. And, if those who claim to be friends of renewables continue to respond to any criticism with hysterics, then they will be responsible for ensuring the budding renewable industry suffers irreparable reputational damage. Because, if the lights keep going out, people will lose faith.

3. Director forced to step down after Princeton Plasma Physics Laboratory reactor fails
The world’s most powerful spherical tokamak will be off-line for a year while new magnets are built.
David Kramer
29 September 2016
The director of the flagship US fusion research laboratory was forced to resign in the wake of a mishap that has caused an extended shutdown of one of the world’s top fusion experiments. The failure two months ago of a magnet at the National Spherical Torus Experiment Upgrade (NSTX-U) is expected to take the machine out of commission for a year.

“The recent technical setback in the NSTX-U facility unexpectedly and suddenly defines a moment that seems to me appropriate” to resign, said a statement from Stewart Prager, who has led the Princeton Plasma Physics Laboratory (PPPL) in New Jersey for eight years. “It is best for new, continuing leadership to shepherd the rebuilding of the facility and the engineering changes that will be needed over the next year.”
A spokesperson at the Department of Energy’s Office of Science, which oversees PPPL, wouldn’t comment on personnel matters. But two sources who declined to be identified said DOE had forced Prager’s resignation; one source called the move an example of the agency’s “buck stops here” contractor management philosophy. A second source corroborates that account: “This was a firing as much as anything else.”
Prager denies that he was asked to resign. “I never spoke to the Office of Science,” he says, adding he had only discussed his resignation with officials at Princeton University, which operates PPPL for DOE. Prager, who is also a professor of astrophysics at Princeton, says he had been considering stepping down since January.

The NSTX-U has been shut down since the end of July, when one of the machine’s 14 magnets, a poloidal field coil, shorted out after 10 weeks of running time, says Mike Zarnstorff, PPPL deputy director for research. Replacing it, and a second identical coil on the opposite side of the tokamak chamber, will take about a year, he says. The machine was nearly due for a scheduled six-month shutdown for maintenance, he notes.

The NSTX-U, a $94 million upgrade of a reactor built in 1999, is the world’s most powerful spherical tokamak, with a design field strength of 1 T and heating power of 10–12 MW. It is a variant of the mainstream tokamak technology at laboratories such as the UK’s Joint European Torus and the ITER international fusion collaboration in France. Tokamaks use magnetic fields to bottle up plasmas of hydrogen isotopes, which heats the confined particles to tens of millions of degrees and causes them to fuse into helium.

Spherical tokamaks are shaped like cored apples, compared with the doughnut shape of conventional tokamaks. The compact shape is designed to confine highly pressurized plasma with weaker magnetic fields than those required at other tokamaks, so the spherical reactors are potentially more cost-effective. The NSTX-U began operations last December and was formally dedicated by Energy secretary Ernest Moniz in April.

Zarnstorff says the root cause of the coil failure is still unknown, although he suspects it was a manufacturing problem. A source close to the lab says the copper wire used in the coil may have been too stiff to accommodate a particular bend in the winding.

The tokamak was operating at half its maximum design field strength when the problem occurred, Zarnstorff says, and full field operation wasn’t planned until next year. The lab has identified four design simplifications to mitigate risks in the replacement coils. A second defect, a damaged copper cooling tube, was discovered when the machine was taken apart. “We know that copper was an unwise choice,” Zarnstorff says. “It should have been made of stainless steel.”

During the shutdown, the lab will review the entire NSTX-U design to determine how to implement beneficial design changes and mitigate further risks. “We’ll have to wait and see and do the [analysis] work,” Zarnstorff says.

Prager will continue to conduct research at the laboratory. Terry Brog, who moved from Pacific Northwest National Laboratory in July to become PPPL deputy director for operations, will serve as acting director.

4.

**ENERGY**

**Flagship U.S. Fusion Reactor Breaks Down**

A design flaw introduced during a recent upgrade could keep the reactor offline for at least a year

By Jeff Tollefson, Nature magazine on September 30, 2016

[https://www.scientificamerican.com/article/flagship-u-s-fusion-reactor-breaks-down/]
A tough year just got tougher for US fusion researchers. The country’s flagship experimental fusion reactor has broken down, less than a year after completing a four-year, US$94-million upgrade. Now officials at the Princeton Plasma Physics Laboratory (PPPL) in New Jersey are investigating whether problems encountered during fabrication of a key component caused the reactor to fail.

Lab officials say that the machine could be offline for up to a year. Making matters worse, one of the other two fusion reactors funded by the US Department of Energy (DOE) is scheduled to shut down on 30 September. That leaves US scientists with just one major facility to conduct fusion experiments, at the defence contractor General Atomics in San Diego, California.

“It’s definitely a challenge for everybody,” says Earl Marmar, who oversees the Alcator C-Mod reactor at the Massachusetts Institute of Technology in Cambridge that is shutting down after more than two decades. “We won’t be completely without access to experimental facilities, but it’s definitely not as good as it could have been for the coming year.”

The upgraded Princeton reactor, called the National Spherical Torus Experiment Upgrade (NSTX-U), is twice as powerful as its predecessor. Like other 'tokamak' reactors, including the international ITER project under construction in France, the spherical machine uses magnetic fields to confine a hydrogen plasma. That plasma is then heated until the atoms fuse and release energy. In theory, fusion could power the world indefinitely—and cleanly.
The Princeton machine’s breakdown came to light on 27 September, after PPPL director Stewart Prager resigned. Laboratory officials say that the upgraded reactor started operating at low power in December 2015 and produced 10 weeks of high-quality data. Scientists shut it down in July after discovering that one of the coils that creates the electromagnetic trap was malfunctioning. Prager says he was thinking about stepping down as director before the reactor coil broke. He elected to depart now, after eight years, so that new leadership can carry the investigation forward and repair the machine. “It’s sort of a normal passing of the baton,” he says.

HUNTING FOR CLUES
PPPL officials initially declined to speculate about the cause of the coil malfunction, saying that an investigation is under way. But the lab later confirmed to *Nature* that questions about the strength of the copper in the faulty coil arose, and were investigated, when the part was being fabricated.
That fact that these concerns arose during the tokamak upgrade suggests that a more careful analysis could have prevented the reactor failure, says Stephen Dean, president of Fusion Power Associates, an advocacy group in Gaithersburg, Maryland. “Mistakes like this do sometimes get made, but with all of the experience the fusion programme has, it should not have happened this way.”

NSTX-U programme director Jonathan Menard says that the finished coil met the laboratory’s specifications. He adds that it is not clear whether
the part’s design or the manufacturing process caused problems. Another coil in the reactor, of a similar design and fabricated from the same grade of copper, has functioned well. The laboratory is planning to replace it nonetheless.

A former researcher at the Princeton laboratory, who declined to be named because he is not authorized to speak about the issue, says that the copper in the faulty coil might have been stronger than it needed to be. That made it harder to bend the metal into the desired shape. Even tiny faults in fabrication can cause problems when energy is coursing through the reactor, heating up the coils.

Menard says that after the coil malfunctioned, X-ray analyses found structural anomalies that may have resulted from internal melting when the reactor was operating. PPPL scientists plan to cut the coil open for further investigations. “We are going to have to wait for those results to make a more definitive statement,” he says.

UNCERTAIN FUTURE

Officials aren’t sure how much it will cost to repair the reactor, but say that it could take up to a year to bring it back online. Because the fusion reactor was already scheduled to halt operations in late 2016 for six months of maintenance, the net loss of research time may wind up being about six months.

The breakdown’s impacts could extend well beyond the Princeton lab. Marmar had planned to shift people to the Princeton facility once MIT’s Alcator reactor shut down. Now, MIT researchers will help Princeton restart its reactor—and try to conduct their previously planned research by collaborating with teams at General Atomics' reactor and facilities.
in other countries.
The DOE decided several years ago to shutter the MIT reactor, but to maintain facilities in Princeton and San Diego. The US Congress reversed that decision once, in 2014, but the US government's 2016 budget assumes that the MIT reactor will shut down.
The DOE says that the US fusion-research programme remains on a solid footing, with extensive international partnerships, and will be back at full strength once the Princeton machine returns to service. Others are concerned about how researchers will cope with only one major US reactor in operation.
Dean thinks the agency ought to keep Alcator C-Mod running another year, until the Princeton reactor is fixed. “It’s not a good situation for our scientists to only have one machine running,” he says.
Marmar is ready to restart the MIT reactor if the DOE changes its mind. “The C-Mod facility is planned to be put into a safe shutdown state,” he says, “but if desired, could be brought back into service on short notice to support the US and international fusion community.”
This article is reproduced with permission and was first published on September 30, 2016.

5. EU reaffirms support for ‘challenging’ fusion project
Éanna Kelly, Science|Business
Climate Commissioner says the giant ITER project has made important managerial ‘turnarounds’, after the European Parliament refused to sign off the 2015 accounts earlier this
year
http://www.sciencebusiness.net/news/79936/EU-reaffirms-support-for-challenging-fusion-project

The EU Commissioner for climate change Miguel Arias Cañete hailed important “turnarounds” in the management of the world’s largest fusion experiment, the International Thermonuclear Experimental Reactor (ITER), as he reaffirmed the EU’s support for the giant project.

Speaking to MEPs on Monday, Cañete said, “ITER stands out as one of the most promising, yet challenging, solutions to energy demand and can entirely reshape the world’s energy map.”

The EU is contributing €6.6 billion to ITER, which has encountered a series of management difficulties, increase of costs and delays since its start. These troubles are “commonly inherent to any large-scale first-of-a-kind project,” Cañete said.

The building of ITER is now six years behind in its official schedule. However, Cañete claimed the management has, “succeeded in making a major turnaround to the project trend, stabilising it and addressing the concerns on the delays and cost overruns.”

Criticisms of the project were heard in April, when the Parliament’s budgetary control committee refused to sign off on ITER’s 2015 accounts, citing ballooning costs and delays.

MEPs said ITER's budgetary and financial management lacked coherence and was often incomplete, criticising the management for its failure to publish a new action plan.

Instead of receiving a routine tick, ITER management instead faced demands to demonstrate improvements in the project’s financial management.

This was not the first setback for the project, which aims to prove the technical feasibility of nuclear fusion as a source of energy. In 2014, a highly critical outside assessment described a litany of problems including bureaucracy, the lack of a "project culture" and "unacceptably slow progress".

But the rocky road has smoothed out, Cañete reported. “I would like to highlight that more than a half of the milestones planned for this year are already completed, and the remaining ones are expected to be finished on time,” he said.

The project, a complex jigsaw which requires one million components paid for through a special ITER currency, has already generated a number of advances in fields as diverse as metrology, robotics and waste processing, Cañete added.

It has also been a boon for industry and research centres. “Between 2008 and 2015, [there were] over 750 contracts and 150 research grants related to ITER for an amount of about €3.6 billion,” the Commissioner said.

6. Director of U.S. fusion lab steps downs as
researchers struggle to repair flagship machine

By Adrian Cho
Sep. 27, 2016, 4:45 PM

Stewart Prager has stepped down as director of the Princeton Plasma Physics Laboratory (PPPL) in New Jersey, the lab announced in a statement yesterday. Prager's departure comes in the aftermath of a malfunction that has knocked the lab's main facility out of action—for perhaps as long as a year. The accident may also spell further trouble for the Department of Energy's $438 million Fusion Energy Sciences (FES) program, which funds PPPL and has already been the subject of battles among budgetmakers at the White House and in Congress.

With a staff of 500 and an annual budget of $100 million, PPPL performs research on nuclear fusion, the process that powers the sun, to help develop it as a source of energy. In particular, PPPL physicists aim to study the fusion of deuterium nuclei trapped in strong magnetic fields within the lab's National Spherical Torus Experiment (NSTX). First switched on in 1999, the NSTX differs from the usual magnetic-confinement fusion device, or tokamak, in that the chamber that holds the plasma looks less like a donut and more like a cored apple. Between 2012 and last year, it underwent a $94 million upgrade to double the strength of the its main magnetic field and add a second port to inject neutral atoms to heat the plasma, which can reach temperatures above 15,000,000°C, hotter than the sun. With the upgrade, the machine became known as NSTX-U.

However, in August a magnetic coil failed, rendering the machine inoperable. Two teams of researchers from PPPL and beyond are now studying the malfunction, says Larry Bernard, spokesperson for PPPL. "There’s a forensic team
that's trying to figure out what went wrong and a design team to figure out how to fix it," he says. Parts of the machine might have to be redesigned and rebuilt. The time frame for doing so remains unclear but could be as long as a year, Bernard says.

Meanwhile, Prager says in the statement that after 8 years as director he was already thinking of stepping down. “The recent technical setback in the NSTX-U facility unexpectedly and suddenly defines a moment that seems to me appropriate for that transition," he says in the statement. "It is best for new, continuing leadership to shepherd the rebuilding of the facility and the engineering changes that will be needed over the next year.” PPPL’s Terry Brog will serve as acting director until a new director is chosen.

The troubles at PPPL come as the FES program finds itself under increasing budget pressure. For the 2017 fiscal year, which begins 1 October, White House budgetmakers requested a cut in the FES budget of 9.2% to $398 million. In their markup of the budget, Senate appropriators would cut the FES budget even further to $280 million. (Unlike the White House request, however, the Senate mark would zero out the U.S. contribution to ITER, a far bigger tokamak under construction in Cadarache, France. This year that contribution is $115 million, and the White House had requested $125 million for next year.) In contrast, in their markup House of Representatives appropriators opted to boost FES spending 2.7% to $450 million (including $125 million for ITER).

It may be several months before lawmakers reach clarity on the fusion budget. Congress is expected to pass a temporary spending bill this week that would freeze 2017 funding at current levels until at least early December, so the FES’s budget would remain unchanged, at least temporarily. Meanwhile, PPPL researchers will be working to right their ship.

*Updated, 9/27/2016: The story has been updated to clarify*
comments from spokesperson Larry Bernard.

7. **Future of fusion**
   
   On Monday, October 10, 2016, the Russian ITER Domestic Agency welcomed the 1st and 2nd year students of the Department of Problems of Physics and Energetics (DPPE), Moscow Institute of Physics and Technology (MIPT).
   

   It were students of the Chair of Plasma Energy, DPPE, who paid fact-finding visit to the Project Center ITER. This is the basic and fundamental chair for training the young specialists for fusion research, and, inter alia, the ITER Project. Students, who are now choosing their professional path and circle of interests, got the opportunity to get acquainted with the World’s most challenging sci-tech project of today, its current status, with those urgent challenges, that researchers and engineers are facing now.

   For this purpose, Anatoly Krasilnikov, Director of the Project Center ITER, and Valery Safronov, TRO for First Wall Panels and deputy head of the Chair of Plasma Energy, shared their thoughts regarding the Project’s prospects.

   After the end of formal part, students used the chance to ask their questions during the free communication.

8. **Nuclear fusion reactor ITER's construction accelerates as cost estimate swells**

   [Thu Oct 6, 2016 5:22pm GMT](http://af.reuters.com/article/energyOilNews/idAFL5N1CC4VW)

   [http://af.reuters.com/article/energyOilNews/idAFL5N1CC4VW](http://af.reuters.com/article/energyOilNews/idAFL5N1CC4VW)
Construction of experimental reactor well under way

New ITER chief estimates total cost at 18 billion euros

Costs hard to estimate as partners contribute in kind

By Geert De Clercq

CADARACHE, France, Oct 6 (Reuters) - Construction of an experimental nuclear fusion reactor in southern France is in full swing as the cost estimate has ballooned to nearly four times the original estimate, but the ITER project's new head says new forecasts are realistic.

The seven partners in the International Thermonuclear Experimental Reactor (ITER) - Europe, United States, China, India, Japan, Russia and South Korea - launched the project 10 years ago with a 5 billion euro ($5.6 billion) cost estimate and plans to heat the first plasma by 2020 and achieve full fusion by 2023. By 2011, the budget forecast had swollen to about 16 billion euros.

In May, new ITER chief Bernard Bigot - former head of French nuclear state agency CEA - told a French newspaper ITER would be delayed by more than a decade and incur another 4 billion euros of cost overruns, with the first test of its super-heated plasma not before 2025 and its first full-power fusion not before 2035.

Unlike existing fission reactors, which produce energy by splitting atoms, ITER would generate power by combining atoms in a process similar to the nuclear fusion that produces the energy of the sun.

"We expect first plasma in December 2025 and full power by 2035. For sure, that schedule is still challenging but it is the best technically achievable schedule, taking into account the financial constraints," Bigot told reporters during a visit to the ITER site in rural Cadarache.

Bigot estimates the overall cost until commissioning will be of the order of 18 billion euros. Compared to the 2010 baseline, the cost increase is about 4 billion euros, he said.

"For the first time, we have a reliable estimate ... In the past there was no realistic schedule, no detailed appreciation of the cost ... It was much underestimated," said Bigot, who succeeded Japan's Osamu Motojima as ITER head early last year.

He said that giving a precise estimate is difficult as partner countries contribute most of their shares in the project in kind, by producing components.

"Many domestic agencies do not want to disclose their exact
costs," he said. He said that only the contribution of Europe, which funds 45 percent of ITER, and that of the United States are released to the public. Bigot said the running cost of the ITER organisation plus the domestic agencies in the partner countries is about 200 million euros per year. Any delay to the project automatically increases the cost by that much. Laban Coblentz, ITER head of communication, said that since partner countries contribute about 80 percent of the value of the project in kind, it is difficult to give precise cost estimates. "This is the source of the inaccuracy when we try to compile the total number," he said. Coblentz said ITER estimates the total project cost at between 18 to 22 billion euros. "If all partner countries had European levels of cost and bureaucracy and you extrapolate based on European costs, it would be at the higher end of the range ... Cost could be up to 22 billion euros at the maximum," he said. Construction at the ITER site in rural Cadarache got under way in 2013-14, but has accelerated from April-May 2015 onwards. "We have seen more progress in the last six months than in the last three years," Coblentz said. Laurent Schmieder, head of construction at ITER, said by 2019 the building that will house the so-called tokamak fusion reactor will be complete. The cost of the buildings alone at the complex will be about 2 billion euros, he said.

The challenges of replicating the fusion process on earth are enormous and critics say it remains unclear whether the technology will work and eventually be commercially viable. ($1 = 0.8964 euros) (Editing by David Evans)

9. **Momentum builds on world’s biggest fusion reactor**

*Posted on October 5, 2016 by districtenergy*

*Future Power Magazine (Net Resources International [NRI]) reports on the latest progress in nuclear fusion. The report notes that fusion power is the ultimate carbon-free energy source, but getting net energy out of the process is not yet practically viable. It currently takes more energy to initiate and contain a fusion reaction*
than the amount of energy produced.
http://www.districtenergy.org/blog/2016/10/05/momentum-builds-on-worlds-biggest-fusion-reactor/

The gap is slowly but surely closing, says the report, and ITER, a massive international coalition to build the world’s most advanced tokamak—the world’s leading controlled thermonuclear fusion power technology—is the leading contender for a breakthrough. ITER, which means “the way” in Latin, is a collaboration between 35 nations, including the UK, US, Russia, China and South Korea, to build a tokamak designed to produce 500 MW of power from 50 MW of input.

<table>
<thead>
<tr>
<th>Main construction milestones:</th>
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<tr>
<td>2006 Signature of the ITER Agreement</td>
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<tr>
<td>2007-2009 Land clearing and levelling</td>
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<tr>
<td>2010-2014 Ground support structure and seismic foundations for the Tokamak</td>
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<tr>
<td>2014-2021 Construction of the Tokamak Building (access for first assembly activities in 2019)</td>
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<tr>
<td>2010-2021 Construction of the ITER plant and auxiliary buildings for First Plasma</td>
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<tr>
<td>2018-2025 Assembly phase 1</td>
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<td>Dec 2025 First Plasma</td>
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ITER’s schedule of main construction milestones for the new Tokamak project. (Data: ITER)

The current record held for power produced vs. input is by the European tokamak JET, which produced 16 MW of fusion power from a total input power of 24 MW in 1997. Last June, ITER appointed MOMENTUM, a joint venture between Amec Foster Wheeler, Assystem and KEPCO—in a €174 million, 10-year contract to start the initial preparation period.

“Technically, ITER is a first of a kind so in many areas we are pushing technical boundaries, we are building things we have never built before,” says Ian Chapman, a senior fusion scientists who was recently appointed CEO of Culham Centre for Fusion Energy (CCFE), the UK’s laboratory for fusion research. The system will use magnetically confined fusion compared with inertial confined fusion, which is used at the U.S Lawrence
Large volumes of data from ITER successfully transferred to Japan at unprecedented speeds

October 4, 2016

The National Institutes for Quantum and Radiological Science and Technology (QST), in collaboration with the National Institutes of Natural Sciences (NINS) National Institute for Fusion Science (NIFS), the National Institute of Information and Communications Technology (NICT) National Institute of Informatics (NII), and the ITER International Fusion Energy Organization (ITER), have connected a dedicated broadband network between one server in ITER and another in the ITER Remote Experiment Centre (REC) in Japan. Using this network they have repeatedly demonstrated the stable high-speed transfer (approximately 7.9 Gbps) of 1TB of data within 30 minutes, the assumed conditions in the initial experiments of ITER. This achievement is the result of a synergetic effect from collaboration in state-of-art information science and technologies and in remote cooperation for nuclear fusion research. These results are a big step towards the construction of the REC in Japan, 10,000km away from ITER. The amount of transferred data of 50TB per day is the world largest level inter-continental high speed data transfer from one site to another site.

The computer network technology of present uses the TCP/IP protocol, especially for the transfer of scientific technical data. In simple terms, with TCP/IP data is sent only after an acknowledgment is received. This means that as the distance increases, the data transfer rate decreases. This problem is solved with Massively Multi-Connection File Transfer Protocol (MMCFTP). Developed by NII, it is one of the world's fastest protocols for international cooperation in cutting-edge science and
technology fields. In parallel, the SINET5 network, operated by NII, commenced operations in April of this year. This direct link between Europe and Japan reduces the communication distance between the two. A broadband dedicated link (10 Gbps) between the ITER and the REC site was also constructed. Using this dedicated line and data generated from the LHD device at NIFS, a large amount of experimental data, assumed to be 1 TB in the initial ITER experiments, was successfully transferred to the remote site. By transferring the data and constructing a data mirror site (duplicate site), there is hope that this mirror will help contribute to "big data" analyses in the fusion energy field and as a failsafe against natural disasters, serve as a remote backup. The results will be presented at the IAEA Fusion Energy Conference in Kyoto from October 17th to 22nd, 2016.

**Background and purpose of research development**

As part of the BA activities, the ITER Remote Experimentation Centre (REC) is being prepared in Rokkasho, Aomori, Japan (Fig. 1). The REC will be able to participate remotely in experiments at ITER from Rokkasho. In addition, by transferring and storing ITER's experimental data and creating a database locally, it will be possible for researchers around Japan to access the data with a lower latency and analyze the experiments more effectively.

This requires all experiment data from ITER to be transferred to REC in its entirety, however, transfer speed decreases drastically when the transfer distance increases, such as with the distance between EU and Japan, because of the limitations of the TCP/IP protocol and the bandwidth of the network.

NIFS conducted high-speed data tests between ITER and Japan in September 2009, and a transfer speed of up to 3.5 Gbps was maintained for 205 seconds (86 GB of data was transferred). However, this was not enough to
transfer the entire amount of data per day generated from the experiments at ITER.
The amount of data generated from each experiment in ITER is massive, and it must be analyzed rapidly between experiments at a pace of about every 30 minutes to an hour. This means the data must be transferred to REC within that timeframe.

Method and results of research
The 5th generation of the SINET network "SINET 5", developed and operated by NII, is a game changer. A direct link 20 Gbps broadband network between Japan and Europe has been established, and the distance of the network line has become shorter than ever (Fig. 2). In addition, by constructing a dedicated virtual private network (L2VPN) between Rokkasho and ITER, a stable, highly-secure broadband network was created in collaboration with GÉANT, that operates the pan-European network for the research and education community, and RENATER, that operates the national research and education network in France. Moreover, in order to simulate the experimental data including various data generated in the actual fusion device, these tests used data generated from actual fusion experiments from a real fusion device, the LHD operated by NIFS.

With the TCP/IP protocol, data is only sent after an acknowledgment is received in order to confirm that each packet being sent is correct. Over long distances, it takes a long time for the confirmation of each sending packet to arrive. As a result, the data transfer speed for large amounts of data decreases drastically. Massively Multi-Connection File Transfer Protocol (MMCFTP), developed by NII for transferring big data in the interest of international cooperation of science and technology, is one of the world's fastest protocols for transferring data over long distances. In MMCFTP, the high-speed data transfer of massive amounts of data is done by splitting the data file, creating multiple connections simultaneously, and balancing the amount that is sent over each connection to keep a steady speed. MMCFTP was adopted for the nuclear fusion field so the full capability of the network connection could be exercised. As a result, the entire amount of data estimated to be generated in the initial experiments at ITER (1TB) can be transferred within the limited time window between experiments.

By connecting the servers in ITER and REC with a dedicated
broadband network, the massive amount of data, around 1.05 TB, can be transferred every 30 minutes at high speed (7.9 Gbps at maximum and 7.2 Gbps at average measured from the ITER side server) for 50 hours. This is the first time that the total amount of data estimated to be generated at ITER per day, around 50 TB, was successfully transferred. (Fig. 3). These results are a big step towards the construction of the REC in Japan. This achievement shows that the data estimated to be generated in the initial experiments in ITER (1TB per experiment) can be transferred in their entirety to the REC in under 30 minutes, which is consistent with the estimated interval between experiments of about 30 minutes to an hour. Further development of this technology will allow the massive amounts of data expected to be produced when ITER is in full operation (about 50 TB per experiment).

The massive amount of data obtained from experiments in ITER will become an important database. By transferring the data and constructing a data mirror site (duplicate site), there is hope that this mirror will help contribute to "big data" analyses in the fusion energy field and as a failsafe against natural disasters, serve as a remote backup.

11. ENGINEERS AUSTRALIA
05/10/2016 | News release | Distributed by Public on 05/10/2016 00:50

Australia Gets Opportunity To Work On Fusion Project

[Link to the source article]

Australia's nuclear agency ANSTO has signed an agreement with the ITER International Fusion Energy Organisation that will see it lend expertise on the ITER fusion project taking place in southern France. ITER was born in 1985 as the Cold War started to thaw and the then presidents of the US and USSR, Ronald Reagan and Mikhail Gorbachev, agreed to collaborate to develop a fusion reactor for peaceful purposes. They were quickly joined by the European Union and Japan and
The agreement with Australia marks the first time a non-ITER member has been allowed to work on the project. 'This is a landmark day in the history of nuclear science in Australia,' said ANSTO CEO Dr Adi Paterson. 'Fusion is the Holy Grail for energy production and if achieved at a large-scale would answer some of the world's most pressing questions relating to sustainability, climate change and security.'

Paterson said, in addition to ANSTO, Australian participants include the ANU, University of Sydney, Curtin University, University of Newcastle, University of Wollongong and Macquarie University. They will work with international experts, determining the feasibility of fusion energy as a large-scale, greenhouse gas-free energy source.

'ANSTO will use its expertise in nuclear techniques to measure the impact of the reactor vessel materials, which are placed under extreme heat and radiation inside the reactor,' said Paterson. 'The state-of-the-art reactor wall materials are a core component of the project and their performance is vitally important.'

David Campbell, who heads ITER's Science & Operations Department, described it as a fundamental change for the organisation. 'Although the fusion R&D activities in the ITER Members make up the vast majority of the international research program on fusion energy development, this is a first step in expanding our research collaborations into the wider fusion community, where there is significant, and in some cases unique, expertise,' said Campbell. 'There is considerable potential for both the Australian and ITER fusion communities in such collaboration.'
power to global fusion energy project ITER

ANSTO’s CEO has signed an agreement with the Director-General of the ITER International Fusion Energy Organisation to join an international consortium of countries that will lend expertise on the ground-breaking ITER fusion project in southern France. [http://www.ansto.gov.au/AboutANSTO/MediaCentre/News/ACS107046](http://www.ansto.gov.au/AboutANSTO/MediaCentre/News/ACS107046)

Seven member entities, comprising 35 countries, are collaborating to build ITER - in the largest engineering project in the world. Scheduled to begin operations in 2025, ITER will be the first fusion device to produce more energy than it consumes.

Major components of ITER are being constructed by the member nations around the world and assembled at the ITER site in France. This is the first time a non-ITER member country has reached a technical cooperation agreement to work on the project, and connects the Australian community of fusion experts with those from the European Union, China, India, Japan, Russia, the United States and South Korea.

Australian researchers and innovators will now work with international experts on this massive engineering project, determining the feasibility of fusion energy as a large-scale, greenhouse gas-free energy source.

As a representative of the Australian nuclear fusion research community on international bodies, ANSTO’s involvement allows all relevant Australian researchers to engage with ITER.

Speaking at the ITER facility in Saint-Paul-lez-Durance, during the signing ceremony with the ITER Director-General Bernard Bigot and accompanied by ANU Professor John Howard, ANSTO CEO Dr Adi Paterson said, “This is a landmark day in the history of nuclear science in Australia.”

“Fusion is the Holy Grail for energy production and if achieved at a large-scale would answer some of the world’s most pressing questions relating to sustainability, climate change and security,” he said.

“Fusion energy holds the promise of a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.

“This agreement is the mechanism through which Australians will be able to engage with ITER. In addition to ANSTO, Australian
participants include the ANU, the University of Sydney, Curtin University, the University of Newcastle, the University of Wollongong and Macquarie University.

“The benefits from this agreement will begin almost immediately. It will clear the way for John’s team from ANU’s Australian Plasma Fusion Research Facility to install an Australian-developed plasma imaging system in the ITER reactor in France.”

The signing of this agreement also delivers one of the major recommendations of the 10-year strategic plan for Australian fusion science, "Powering Ahead A National Response to the Rise of the International Fusion Power Program", which was released in 2014. The strategic plan was developed by the Australian ITER Forum. Read more: http://fusion.ainse.edu.au.

Fusion energy is released by the merging of hydrogen into helium - the process which powers the Sun - and if it could be safely harnessed on Earth it could provide clean, base-load power for millions of years.

The ITER project was established in 2006 and the first plasma is expected to be produced by December 2025. You can find out more about fusion energy and ANSTO here.

DETAILED INFORMATION ABOUT THE PROJECT

The Global Fusion Energy project centres on the construction of the world’s largest tokamak, a magnetic fusion device or reactor, which harnesses the energy of fusion and captures this heat in the walls of the vessel.

Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators.

The difference is there are no harmful greenhouse-gas emissions as a result, and very low levels of radioactive waste.

Thousands of engineers and scientists have contributed to the design of ITER since the idea for an international joint experiment in fusion was first launched in 1985. The ITER Members—China, the European Union, India, Japan, Korea, Russia and the United States—are now engaged in a 35-year collaboration to build and operate the ITER experimental device, and together bring fusion to the point where a demonstration fusion reactor can be designed.

Australia does not have nuclear power, but we do have relevant expertise. The plasma provides the environment in which light elements can fuse and yield energy, and this is where ANSTO comes in.

“ANSTO will use its expertise in nuclear techniques to measure the
impact of the reactor vessel materials, which are placed under extreme heat and radiation inside the reactor,” said Paterson. “The state-of-the-art reactor wall materials are a core component of the project and their performance is vitally important.”

For more information on ITER, please visit the ITER website: 
http://www.iter.org/newsline/  
https://www.iter.org/proj/inafewlines  
https://www.iter.org/faq

ANSTO Media contact: Phil McCall on 0438 619 987

13. High-intensity fusion
MIT’s Alcator C-Mod nuclear reactor winds down — and defines its legacy on its final run.
Meg Murphy | School of Engineering
October 14, 2016
http://news.mit.edu/2016/high-intensity-fusion-1014

Pablo Rodriguez Fernandez is hunched over a computer in the control room of MIT’s fusion reactor, gathering data that will inform the design of a new one — a device that could solve the world’s energy problems. He is surrounded by other scientists running simulations and analyzing data. Their work is spread across tables and desks covered in computers and a chaos of wires. The objective: to design a machine that will harness the same energy process that powers the sun and deliver it to the world, carbon free. They are here to make fusion energy a reality.

This is the headquarters of a MIT’s Alcator C-Mod. A fixture on campus for 23 years, C-Mod uses high-intensity magnetic fields to confine hot plasma in a donut-shaped chamber — a reactor design known as a tokamak, a transliteration of a Russian word for “toroidal chamber.” During C-Mod’s final run, the reactor’s team of operators will take MIT’s high pressure world record to an extraordinary new level. It will create renewed hope that a faster path to clean and safe energy is before us.
On this day in mid-September, as Fernandez and his fellow graduate students in the Department of Nuclear Science and Engineering type, calculate, and predict, the machine is operating on the other side of a nearby concrete wall. Fernandez, along with PhD candidates Alex Creely and Juan Ruiz Ruiz, have joined research scientist Nathan Howard to run a code that combines plasma measurements from several tokamaks, including C-Mod, into a single model. They have worked on other tokamaks, such as NSTX at the Princeton Plasma Physics Lab, ASDEX-Upgrade at the Max Planck Institute in Germany, and DIII-D at General Atomics in San Diego. All of them are world-class facilities, but C-Mod's atmosphere is special, say Creely and Fernandez, who are in shorts and sneakers. “It’s less formal at MIT than at the national labs,” says Fernandez. His t-shirt reads, “Changing the World.”

Despite its apparently casual atmosphere, C-Mod has also established stringent safety standards that have been widely exported across the MIT campus. That balance between rigor and flexibility, says Creely, is part of what has made C-Mod such a success. “This is one of the most powerful machines in the world, and graduate students can go in and work, build diagnostics and such, on our own time,” he says. “People are open to you attaching new things and making modifications. It’s just this awesome university feel here,” he adds. He nods toward the scientists with legs draped over the backs of office chairs, the bike helmets, water bottles, Coke cans, and the student lab equipment decorated, in some instances, with beer logos and political slogans. “We have people from physics, aero-astro, nuclear engineering, wherever. All this expertise in one location. And you can just go talk to people.”

Indeed, even before its final experiment changed the debate over field intensity and materials, the world of fusion science owed a great debt to C-Mod. The machine has been at the heart of energy experiments that have shaped the careers of hundreds of scientists and engineers. It has inspired almost 200 doctoral theses, dynamic collaborations, and scientific breakthroughs. It has been the training ground for a whole
generation of plasma scientists. “We’re not just doing science.”
Anne White and her students are striking a campy, dramatic pose for a group photograph. They are in a hallway outside of the control room creating a commemorative record of their time together in the reactor complex on Albany Street. Hanging on the wall behind them are the protective hard hats that are required when entering C-Mod territory. Many of them are personalized with last names. These, too, are on the way to becoming mementoes.
White, the Ida and Cecil Green Professor in Nuclear Engineering, and her team of students are international leaders in assessing and refining the mathematical models used in fusion reactor design. With the closure of C-Mod, White says, she has arranged intensive collaborations with other groups worldwide. These relationships will be key for their research continuing and moving forward.
Later the same afternoon, she and John Rice, a senior research scientist, talk openly about the shutdown. Rice has been at MIT for 45 years. During that time, three Alcator machines have come and gone, but C-Mod will be the last in this line. “I’m probably one of the last people to accept the situation,” Rice says. “I still can’t believe next Friday is going to be the last day.”
The two of them are from different generations. White more formal in a tailored outfit with her blonde hair up in a bun, a pencil stuck through it. Rice with his long gray hair braided down his back in a look reminiscent of the 70s. MIT fusion scientists, they agree, will maintain a broad experimental portfolio and connections to friends around the world.
“We will keep having an impact on the science,” says White. “Students will get a chance to do awesome stuff and write lots of papers and go through the training we think is so important for fusion scientists.”
In 2012, the Department of Energy (DOE) announced the end of funding for the reactor. The White House had decided to invest instead in the International Thermonuclear Experimental Reactor (ITER), which is under construction in
France, a project that draws directly from design and materials advances made in C-Mod. Although MIT’s fusion experiment was slated for elimination in both the 2013 and 2014 fiscal budgets, broad-based advocacy efforts managed to keep it alive until this month.

Government players are at odds when it comes to supporting fusion research. The White House wants to see a 9.2 percent reduction in the DOE’s $438 million Fusion Sciences Program in 2017. Senate appropriators would cut it even further to $280 million— but zero out contributions to ITER and redistribute the money to other energy programs. The House, meanwhile, wants to boost the program spending by 2.7 percent but contribute the bulk — $125 million — to ITER. It may be many months before lawmakers reach clarity on fusion research spending in the U.S.

Now, with the closure looming, Rice is trying to make the best of it. “We have data analysis left to do. We have plans for the future. We have great people who work well together — and we intend to continue to move fusion forward,” he says.

Listening from a few computer terminals away, team member Norman Cao, a graduate student in the nuclear department, adds: “Fusion is a cool place to be. We’re not just doing science. We’re trying to apply it to the real world.”

Fusion science rooted at MIT

In his office across the street, Martin Greenwald, deputy director of MIT’s Plasma Science and Fusion Center, is working hard to get new projects off the ground. The closure of C-Mod is the end of a chapter but it’s not the end of the story, he says. “These machines have their own lifetime. They start, we do research, and they end. Our work will continue.”

Many of the most influential concepts in fusion science have been developed at MIT, says Greenwald. Recently, he came across a 1971 patent for the first of the Alcator machines. Then, as now, the project was focusing on a high-magnetic-field approach to fusion. Indeed the fusion program, born in the early 70s, is a direct result of the synergy between MIT physicists and engineers at the Francis Bitter Magnet Laboratory, which is part of the Plasma Science and Future
Center. “Our magnet group invented an approach to superconducting magnets that is essentially the default today. It’s used by all the big machines in fusion,” says Greenwald. “Now we want to develop magnet technology further.” There is good reason. Fusion reactions are slow until the fuel is heated to unimaginably high temperatures, “over 100 million degrees — far hotter than the core of the sun,” says Greenwald. Then electrons in the fuel atoms are stripped of their nuclei and the gas becomes a plasma, the fourth state of matter. At these temperatures, magnetic fields are the only reliable way to insulate hot plasma from material walls of the reactor. “We’ve attained the necessary plasma densities and temperatures in C-Mod,” says Greenwald. “But Alcator reactors are relatively small. They produce about as much fusion power as they consume.”

Figuring out how to yield net energy production out of a fusion reactor is really the heart of what researchers are pursuing now. The creation of a giant tokamak such as ITER is a massive endeavor. The international effort is projected to exceed $50 billion, which is 10 times the original estimate. Fueled experiments will not begin before 2027 — already more than a decade behind schedule.

There might be alternatives to “going big,” says Greenwald. He describes the MIT-student designed “Affordable, Robust, Compact” (ARC) reactor design proposal, which calls for a smaller, more modular reactor that relies on advances in materials and magnet technology. Such a tokamak could be built at one-tenth the size and cost. To begin, MIT will seek private funding. The Advanced Diverter Experiment, or ADX, is a project MIT would like to develop in parallel. It would be roughly the same size as C-Mod but use a different design. It would tackle several important problems for fusion by enabling researchers to learn more about the behavior of hot plasmas, their interactions with material surfaces, and the behavior of structural materials in a fusion environment. MIT has proposed that the Department of Energy fund it. Greenwald says the easy joke is that fusion energy is the
power source of the future — and always will be. But he believes otherwise. “There is a lot of energy and excitement here about what we could do moving forward. We can hit a home run if we can just get up to bat.”

“Young people are driving the innovations.”

Ten years ago, Dennis Whyte came to MIT in large part because of its fusion program. More specifically, he came because he saw that students were combining their classroom learning with hands-on training at a world-class fusion facility. Today about a third of C-Mod’s experimental leaders are students, says Whyte, head of the Department of Nuclear Science and Engineering and director of the Plasma Science and Fusion Center. “Young people are driving the innovations. They are rethinking old assumptions and really making us think about new ways that we can get to fusion,” he says.

“They are changing how research is done in the modern age.”

The relative youth of the faculty members in Whyte’s department supports his observation. Nine out of 17 are under the age of 40. “The drive that comes from this new generation of fusion scientists is immense,” Whyte says. “Just a few years ago, it did not seem as if we’d be able to make net energy possible.” With a new generation of superconducting materials and a design path blazed by Alcator C-Mod, which firmly established the advantage of using high magnetic fields to achieve fusion energy, “suddenly we have an opportunity to develop extremely compact and very efficient devices,” he says.

“This is what makes MIT great. We get these young people in here and we empower them to actually rethink standard assumptions and try to make the world better through their dedication and talent. And they do it.”

Breaking a record on the final day

Back in the control room, Earl Marmar glances toward several large display screens that entirely cover a front wall. They show him the tokamak is operating at full parameters. Head of the Alcator C-Mod project since 2002, Marmar is not holding the machine back. There was a time he was hesitant to run the reactor at its highest magnetic fields for fear of stressing it.
Those days are over. “For the last few years, we’ve really pushed hard. We’ve learned new things as a result, and we haven’t broken the machine,” he says. “Even now we have new ideas coming. We’re still running for another week. It’s not over yet.”

He says the federal government provided funds to put C-Mod into a safe shutdown state. “It will be in a condition where we could bring it back up to life in the future. Although there is no plan to do that right now. We are heading in new directions.”

The lived-in feel of the control room speaks to the kind of familiarity the scientists, engineers, and students have developed with the machine, and with each other. Over by her team, Anne White speaks with Howard, who says graduate students have benefited greatly from the opportunity to work directly on a tokamak. “We’re doing these collaborations but there is just nothing like having your own machine. Losing it is a sad state of affairs. But we’ll take our skill set that we’ve honed here and apply it to other tokamaks.” Including ones the team hopes to design and build at MIT.

On its final day of operations, C-Mod was still breaking new scientific ground. That morning, the team operating the reactor broke the world record for plasma pressure achieved in a magnetically confined field. The pressure inside C-Mod was 2.05 atmospheres — better, by a factor of 2, than every other tokamak in the world. And these other reactors, which are 20 to 100 times larger in volume than C-Mod, are dwarfed by the scale of ITER, which will be 800 times the volume of C-Mod.

The key difference, says Whyte, is the underlying technology driving C-Mod. “High-magnetic fields are the way to go,” he says. “You couldn’t ask for a more compelling demonstration of how ready our science is for high-field fusion. Even a project on the scale of ITER is only projected to achieve 2.8 atmospheres — and that’s 20 years from now!”

As MIT was celebrating its unprecedented success, Whyte’s fusion-science colleagues at Princeton University were lamenting a loss. Earlier in the same week, they learned that their recently upgraded reactor would be offline for up to a
year due to a coil malfunction, leaving only one major fusion research reactor in operation in the U.S. The situation poses yet another challenge to scientific advancement, but Whyte is undeterred. “We have assembled an incredible science and engineering team,” says Whyte. The openness to new ideas and the collaborative ethos that have powered so many of the C-Mod results will go on, he says. “Our students are using their research and applying it. You can feel the excitement. We want that optimism to reach the community more broadly. We want to get our vision out to the whole world. Let’s accelerate fusion.”

14. Thursday, October 13, 2016, 10:59

Igniting a star on earth for energy
http://www.timesofmalta.com/articles/view/20161013/local/igniting-a-star-on-earth-for-energy.627852

Researchers at the University of Malta are contributing to the construction of the International Thermonuclear Experimental Reactor (ITER). This €20 billion nuclear fusion reactor, known as a tokamak, is being constructed in Cadarache, France and will be the world’s largest machine of its kind. The European Union, the United States, Russia, China, India, Japan and South Korea have all joined forces to build this international experimental magnetic confinement machine to prove the feasibility of nuclear fusion as a large-scale and carbon-free source of energy based on the same principle that powers the sun and stars. ITER is designed to produce net energy and maintain fusion reactions for long periods of time. It will be the first fusion device to test the integrated technologies, materials and physics regimes necessary to build power plants for the commercial production of fusion-based electricity. ITER is designed to make the long-awaited transition from experimental studies of plasma physics to full-scale electricity-producing fusion power stations. Through a collaboration set up with the Paul Scherrer Institute (PSI) in
Villigen Switzerland, Karl Buhagiar, Nicholas Sammut (deputy dean Faculty of ICT) and Andrew Sammut (dean Faculty of Engineering) worked on the measurement and characterisation of the core main elements of the machine.
Nuclear fusion reactions are very challenging to confine sustainably due to the extremely high temperatures involved. However, they release three times as much energy as current fission reactors and their fuels are abundant.
They also produce 100 times less radioactive waste that is not long lived. The design of tokamaks is also such that it would be impossible to undergo large-scale runaway chain reactions. If this technology is harnessed, fusion reactors would be able to produce reliable electricity with virtually zero pollution.

15. **Iter transformer in place as materials tests continue**
11 October 2016
As the first of three Chinese-supplied electrical transformers is installed at the Iter fusion project in France, researchers in the Netherlands are testing the resistance to neutron radiation of materials that will shield the fusion reactor's core.

Dutch radioisotope producer NRG announced today that material to be used in Iter's "first wall" will be irradiated in its High Flux Reactor (HFR) at Petten over the coming months. The plasma in which Iter's nuclear fusion reaction will take place at a temperature of 150 million degrees Kelvin is itself contained by a magnetic field. The first wall provides the first shielding of the reactor's core and will be exposed to the high-energy neutrons produced in the fusion process, which are not contained by the magnetic field.
The first wall will be made of beryllium tiles welded onto a subsurface of copper-chrome-zircon alloy, contained in a stainless steel construction. Scale models, using the same tiles, will be placed in the core of the HFR, which is used to produce radioisotopes, to simulate the environment and temperatures that will be found in Iter.
NRG spokesperson Sander de Groot said: "We can mimic the same conditions as in Iter, and the neutron density in the HFR is high. Within a short period we can use this to simulate radiation damage during the life span in the fusion reactor and determine how long components used in Iter can withstand the neutron radiation."
The irradiated mock-ups will then be transported to the Jülich research centre in Germany, where they will be exposed to extremely high heat flux and intense variable thermal radiation to test the resistance of the irradiated material to the extreme heat load it will be subjected to in Iter.

**Transformer placement**

The 14 metre long, 280 tonne transformer forms part of the electrical network that will provide power to Iter's "pulsed" systems, such as magnet power supplies and plasma heating systems. It was was delivered to the Cadarache site in June. The operation to move the giant component into position from its storage site took nearly two days to complete. First, it was delivered by hydraulic trailer to the installation site, where it was lowered onto railway-type wheels. It was then hauled into its final position along pre-built tracks. Before it becomes operational, the transformer will be filled with insulating oil and fitted with other equipment including the bushings needed to connect it to the switchyard, bringing its total weight to 460 tonnes.

Two other transformers are due to arrive from China in early 2017 to be connected to the switchyard by the middle of the year. Thirty-five nations are collaborating to build Iter, the world's largest tokamak, at Cadarache in the south of France. The magnetic fusion device is designed to prove the feasibility of the fusion of hydrogen nuclei as a large-scale and carbon-free source of energy. The EU is funding half of the cost while the remainder comes in equal parts from six other partners: China, Japan, India, Russia, South Korea and the USA. Construction began in 2010 and the facility is scheduled to generate its first plasma in 2025.

*Researched and written by World Nuclear News*

**16. Grid connection for Pakistan's fourth reactor**

*17 October 2016*

**Pakistan’s Chashma unit 3 was connected to the country’s power grid on 15 October at a ceremony attended by the Pakistan Atomic Energy Commission and China National Nuclear Corporation (CNNC). The unit reached first criticality on 2 October.**


Construction began on the Chinese-designed CNP-300 pressurised water reactor (PWR) in March 2011, and the unit is expected to enter commercial operation before the end of this year.
Chashma 3 is one of two CNP-300 units being built at the site, in Punjab province. Unit 4, which began construction nine months after unit 3, is currently undergoing commissioning and is expected to enter commercial operation in 2017.

The Chashma site - also referred to as Chasnupp - is already home to two Chinese-supplied 300 MWe PWRs: unit 1, in commercial operation since 2000, and unit 2, in commercial operation since 2011. Pakistan also has a 125 MWe Canadian-supplied pressurized heavy water reactor, Karachi unit 1, which has been in commercial operation since 1972.

Two 1161 MWe Chinese-supplied Hualong One plants are also planned at the Karachi site. A ground-breaking ceremony for Karachi 2 was held in August 2015, and the units are scheduled to enter service in 2021 and 2022.

Pakistan is not a party to the international nuclear non-proliferation treaty, but its civil power reactors and its two research reactors all operate under International Atomic Energy Agency safeguards.

Research and written by World Nuclear News

17. Haiyang 1 pumps operated at full-power
14 October 2016

The four reactor coolant pumps at unit 1 of the Haiyang nuclear power plant in China’s Shandong province have been operated simultaneously at full speed for the first time. The AP1000 is set to begin operating by the end of the year.


The four pumps all attained 100% speed at 1.23am on 9 October, State Nuclear Power Technology Corporation (SNPTC) announced in a 12 October statement.

Installation of the fourth and final reactor coolant pump at the Haiyang 1 AP1000 was completed on 25 April. Cold hydrostatic tests of the primary circuit were successfully completed at Haiyang 1 on 2 July. The tests, which involve increasing the pressure within the primary circuit to 21.6 MPa and maintaining it at that level for 11 minutes, aimed to confirm the integrity and sealing of the circuit’s components.

Hot tests of the reactor's primary circuit were officially launched on 20 September. Tests have subsequently been carried out with the pumps operating at 24%, 50% and 88% speed. On 9 October, all the pumps were operated at full-speed for two hours with the water in the reactor coolant system at a temperature of around 275°C.
The pumps were then taken back down to 50% speed. SNPTC said during the tests the pumps operated as normal, "verifying their reliability and stability". In September 2007, Westinghouse and its partners the Shaw Group received authorization to construct four AP1000 units in China: two at Sanmen in Zhejiang province and two more at Haiyang. Sanmen unit 1 is expected to be the first AP1000 to begin operating later this year, while Haiyang 1 is also expected to start up by the end of the year. SNPTC announced last month that the four main pumps at Sanmen 1 had been operated continuously at full speed for five hours as part of the unit's start-up. The company said that, at full-speed, the pumps' vibration, stator temperature and bearing temperature were within the normal range. Four AP1000 reactors are being built in the USA - two each at Vogtle and Summer - while three AP1000s are also proposed for the Moorside site in the UK. 

Research and written by World Nuclear News

18. Contract for nuclear islands of Xudabao Phase I
14 October 2016

A contract has been signed for the civil construction of the nuclear islands for units 1 and 2 of the Xudabao nuclear power plant in China's Liaoning province. The units are the first of six AP1000 reactors planned for the site. http://www.world-nuclear-news.org/NN-Contract-for-nuclear-islands-of-Xudabao-Phase-I-1410164.html

The contract was signed on 10 October by China Nuclear Industry 22 Construction Company (CNI22) general manager Zheng Xiaojun and China Nuclear Power Engineering Company (CNPEC) general manager Liu Wei. CNI22 is a subsidiary of China Nuclear Engineering and Construction Corporation (CNECC), while CNPEC is a subsidiary of China General Nuclear. The signing ceremony was attended by CNECC chief engineer and vice president Huo Lin Zhuang; director of CNECC's nuclear engineering division Yang Zhenhua; and, CNI22 deputy general manager Yang Zhenxun, among others. China's National Nuclear Safety Administration (NNSA) announced its approval of the site selection for Xudabao units 1 and 2 - the first two of six AP1000 units planned there - in April 2014. It said the site, in Xingcheng City on the island of Hulu, would meet site-related aspects of nuclear safety regulations. Final approval was reported in September 2014, and again in December 2015 by the
Site preparation at Xudabao began in November 2010. The National Development and Reform Commission gave its approval for the project in January 2011. However, following the Fukushima accident two months later, Chinese authorities suspended the approval process for new plants. In October 2012 China announced that approvals for inland plants would be delayed until after 2015. Parts that had been intended for the Taohuajiang plant in Hunan province - where four AP1000 units are planned - were subsequently earmarked for Xudabao. Manufacture of the steel containments for the first two Xudabao units was launched in July 2013 by Shandong Nuclear Power Equipment Manufacturing Co Ltd. China National Nuclear Corporation subsidiary Liaoning Nuclear Power Company Limited - set up in March 2009 - is majority owner of the plant, with China Datang holding a 20% stake and the State Development and Investment Corporation holding 10%. CNPEC is the general contractor for the Xudabao project, expected to cost some CNY 110 billion ($16 billion).

Researched and written by World Nuclear News

The Guardian's '100 months to save the planet' was always just a fantasy

CHRISTOPHER BOOKER

http://www.telegraph.co.uk/science/2016/10/08/the-guardians-100-months-to-save-the-planet-was-always-just-a-fa/

8 OCTOBER 2016 • 5:30PM
You may not have noticed, but 2016 was the hottest year for over 100,000 years. At least this was the claim reported last week by The Guardian, under the headline “Planet at its hottest for 115,000 years thanks to climate change, experts say”.

The “experts” in question are a bunch of US scientists led by James Hansen, the former Nasa employee who did so much to set the great global warming scare on its way in 1988. And of course such a claim could only be made by ignoring all the evidence that the earth was actually hotter than today during the Mediaeval Warm Period, less than 1,000 years ago, and even more so during the thousands of years of the Holocene Optimum, following its emergence from the last ice age 10,000 years ago.

But Hansen and his gang do not stop there. They argue that we can only hope to save the planet by finding ways to suck vast quantities of CO2 out of the atmosphere, at a cost, they estimate, of up to $570 trillion. That figure which may trip off the tongue, but it equates to seven times the world’s entire current annual GDP, or $77,000 for every human being now alive.

If this only shows how dottily desperate some of our wilder climate alarmists have become, we may come back to earth a little by focusing on another version of the great climate scare which also got The Guardian very excited eight years ago, when it launched a campaign under the heading “The final countdown”. This proclaimed that we then had only “100 months” left to
save the world from “irreversible climate change”: soaring temperatures, melting ice caps, dangerously rising sea levels, more hurricanes, tornadoes, droughts, and all the other familiar harbingers of catastrophe. Now those “100 months” are up, it has prompted the diligent Paul Homewood to publish on his website, Not A Lot of People Know That, a set of graphs meticulously compiled from official data. The show what has actually happened to the earth’s climate in these past eight years. Despite the 2016 El Nino spike, now rapidly declining, satellite measurements still show that the trend in global temperatures has not risen for 18 years. Far from the ice caps melting, the total amount of polar ice in the world is almost exactly the same in today’s Arctic and Antarctic as it was when satellite records began in 1979. Despite all those computer models predicting otherwise, the rise in global sea levels has been barely detectible, not having accelerated in more than a century. Despite Hurricane Matthew, there has been no increase in the incidence or power of tropical cyclones. Tornadoes in the US have been at a historic low level. The number of severe droughts across the world since the first half of the 20th century has actually declined. All the computer models which predicted these horrors were programmed to assume that they would be the inevitable result of that increase of CO2 in the atmosphere which has steadily continued all through these past 100 months. Yet not one of their predictions has come true. Indeed the most startling of Homewood’s charts (taken from the BBC website, no less) shows that the most obvious consequence of the rise in CO2 has been its effect, as plant food, on the “greening” of the planet, helping to boost a dramatic rise in crop yields across the world.
Yet to all this our politicians remain wholly oblivious. The irony is that 2008, when global warming hysteria was still at its height, was the very year when they landed us with the Climate Change Act, committing us to spending hundreds of billions of pounds on “decarbonising” our economy, at a time when other countries, led by China and India, are planning to increase their own “carbon” emissions by far more each year than the UK’s entire annual contribution to the global total. Until that totally insane Act is repealed, we really are heading for national suicide.

20. Press release: Final contracts signed for Hinkley Point C
By Hinkley Point C media team | September 29, 2016 | HPC news

EDF signs with UK Government and Chinese partner CGN in London. See - Signings mark revival of new nuclear in UK and Europe. - Construction phase for Hinkley Point C now fully launched.

Contracts for the Hinkley Point C nuclear power station in Somerset have been signed today in London.
The signings took place between the Secretary of State for Business, Energy and Industrial Strategy Greg Clark, EDF group Chairman and CEO Jean Bernard-Levy and CGN Chairman He Yu. French Foreign Minister Jean-Marc Ayrault and the Administrator of the Chinese National Energy Administration Nur Bekri attended the ceremony.
The event marks the end of the project’s development phase following years of rigorous preparation and planning.
Today’s signing formally relaunches new nuclear construction in the UK and Europe and will provide a significant boost for industry in Britain and France. The plant’s two EPR reactors will provide reliable, low carbon electricity to meet 7% of the UK’s future electricity needs. Their construction is a major step forward in the fight against climate change.
The project is an essential part of EDF Group’s strategy to be a leading long term investor and developer of low carbon electricity. It strengthens EDF’s presence in the UK where it successfully operates 15 nuclear reactors, serves millions of customers and invests in a wide range of generation technologies.

Hinkley Point C will be competitive with all other future energy choices and it has been shown to offer consumers value for money. It will also have a long-lasting impact on industry, jobs and skills, creating thousands of high quality jobs and apprenticeships in Somerset and across the UK and France. Work to enable the British supply chain to compete for contracts for Hinkley Point C means that EDF now expects 64% of the project’s value to be spent in the UK.

The signings also mark a new chapter in the longstanding partnership between EDF and CGN. Their joint experience in successfully constructing two EPRs at Taishan in China will bring direct benefits to the Hinkley Point C project. Agreements signed today will enable the development of nuclear power stations at Sizewell C in Suffolk and Bradwell B in Essex.

EDF and its partners are now fully dedicated to the successful construction of the Hinkley Point C project which is already well advanced. The EPR reactor design is approved by the UK regulator. Experience from other EPR projects has been fully integrated into Hinkley Point’s planning and design. Early involvement with suppliers and preparatory work in engineering has taken place.

Comprehensive agreements with trade unions are in place covering safety, quality and productivity.

Waste transfer contracts signed today mean that, for the first time in the UK, the full costs of decommissioning and waste management associated with the new power station will be are set aside during generation and are included in the price of the electricity.

EDF confirms again that the first electricity is due to be produced in 2025 and that the construction cost to first operation remains at £18bn nominal (1).

Greg Clark, Secretary of State for Business, Energy and Industrial Strategy said: “Signing the Contract for Difference for Hinkley Point C is a crucial moment in the UK’s first new nuclear power station for a generation and follows new measures put in place by Government to strengthen security and ownership. Britain needs to upgrade its supplies of energy, and we have always been clear that nuclear power stations like Hinkley play an important part in ensuring our future low-carbon energy security.”

EDF Group Chairman Jean-Bernard Levy said: “Contracts signed today with the British Government and with our historic partner CGN are the
result of years of hard work of the teams which have brought us to this point. The project is of strategic importance for EDF Group and the nuclear industry. All of the employees of EDF Group around the world can be proud of the progress we have made. Now the next phase is underway. EDF, its partners and suppliers are ready and dedicated to the successful construction of Hinkley Point C.”

EDF Energy CEO Vincent de Rivaz said: “Hinkley Point C will kickstart Britain’s nuclear revival. It has overcome obstacles and challenges which will benefit our next nuclear projects in Britain. This huge investment has been made possible by the consistent policies of successive Governments to provide secure, affordable, low carbon electricity. I want to thank our team, our suppliers, trade unions and the people of Somerset for their dedication, determination and patience. Their support has been vital to our success.”

(1) Nominal costs, or current costs, refer to the costs expressed in the current money of the time they are incurred. They include the impact of the inflation of each year.