Australian ITER Forum Website News Update 9/17

B.J.Green (19/9/17)

1. Science & Environment

Fusion energy pushed back beyond 2050

By Edwin CartlidgeScience writer

- 11 July 2017

- From the section Science & Environment

http://www.bbc.com/news/science-environment-40558758

We will have to wait until the second half of the century for fusion reactors to start generating electricity, experts have announced.

A new version of a European "road map" lays out the technological hurdles to be overcome if the processes powering the Sun are to be harnessed on Earth.

The road map has been drawn up by scientists and engineers at EUROfusion.

This is a consortium of European laboratories and universities that funds research on fusion energy.

The original version of the road map, published in 2012, forecast that a demonstration fusion power plant known as DEMO could be operating in the early 2040s, in order to supply electricity to the grid by 2050.

But in the updated version, yet to be released, DEMO would not start running until "early in the second half of the century".

A related document that provides more detail on DEMO's design says that operations would start after 2054.

The setback has been caused largely by delays to ITER, a 20bn-euro reactor that is currently being built in the south of France to prove that fusion energy is scientifically and technically feasible.

In fact, according to EUROfusion's programme manager, nuclear physicist Tony Donné, DEMO's schedule could slip further, depending on progress both with ITER and a facility to test materials for fusion power plants that has yet to be built.

"2054 is optimistic," he says. "It is doable but we need to align political decision makers and get industry involved."

Fusion involves heating nuclei of light atoms - usually isotopes of hydrogen - to temperatures many times higher than that at the centre of the Sun so that they can overcome their mutual repulsion and join together to form a heavier nucleus, giving off huge amounts of energy in the process.

In principle, this energy could provide low-carbon "baseload" electricity to the grid using very plentiful raw materials and generating relatively short-lived nuclear waste. But achieving fusion in the laboratory is a daunting task.

Doughnut-shaped reactors known as tokamaks use enormous magnetic fields to hold a hot plasma of nuclei and their dissociated electrons in place for long enough and at a high enough density to permit fusion.

ITER, in fact, represents the culmination of 60 years of research. The world's largest ever tokamak, it will weigh 23,000 tonnes and is designed to generate 10 times the power that it consumes.

But the project has been beset by delays and cost overruns. Originally foreseen to switch on in 2016 and cost around 5bn euros, its price has since roughly quadrupled and its start-up pushed back to 2025. Full-scale experiments are now not foreseen until at least 2035.

As well as being technically very demanding, ITER is also complex politically.

It is an international project with seven partners: China, the European Union, India, Japan, South Korea, Russia and the United States. As host, Europe is paying the biggest share of the costs - about 45%.

European research organisations set up the road map five years ago to guide the research needed to achieve fusion electricity by 2050. In doing so, they were mindful of competition from other ITER partners; both China and South Korea having started to design their own demonstration reactors.

The roadmap sees ITER as the single most important project in realising fusion but not one that is designed to generate electricity.

DEMO, a tokamak adapted from the ITER design which would also cost billions of euros, is intended to produce several hundred megawatts of electricity for the grid. To do so, it must run continuously for hours, days or ideally years at a time, as opposed to ITER, which will operate in bursts lasting just a few minutes.

In addition, DEMO will have to generate its own supply of tritium (the radioactive isotope of hydrogen which can help drive fusion) by using neutrons it produces to transform lithium (its other hydrogen isotope, deuterium, can instead be extracted from sea water).

Researchers are already starting to develop conceptual designs for DEMO. But because they need results from ITER to draw up a detailed engineering design, their progress is vulnerable to any further delays in France.

The person who coordinates this work, EUROfusion nuclear engineer Gianfranco Federici, describes the revised road map as "realistic but very ambitious". He says its success will depend not only on progress with ITER but also on the heads of European labs sacrificing some of their own research projects to concentrate on the design and R&D laid out in the plan.

He reckons that this shift in priorities will not be easy. He says that physicists "are searching for the holy grail, the perfect plasma", whereas the roadmap embodies a more "pragmatic" approach to realise fusion energy as quickly as possible.

Federici argues it is vital to demonstrate electricity generation from fusion "not too far after the middle of the century". Otherwise, he says, there may no longer be a nuclear industry able to build the commercial fusion plants that would follow, and the public may lose patience.

The subsequent loss of political support, he wrote in the DEMO design report, "would run the risk of delaying fusion electricity well into the 22nd century."

Robert Goldston, a physicist at the Princeton Plasma Physics Laboratory in the US, is more optimistic. He is "very confident" that ITER can produce "industrial amounts of heat" and believes that once it has done so generating electricity from fusion will be "a question of commitment of manpower".

But he says that commercial power plants won't necessarily use tokamaks. An alternative, he says, is the stellarator - a reactor exploiting strangely-shaped magnets that is hard to build but potentially easier to operate.

Meanwhile, in recent years a number of private companies have started investigating smaller, cheaper alternatives.

One such company is Tokamak Energy in Oxfordshire, which is developing a spherical-shaped tokamak that creates magnetic fields using high-temperature superconductors. The firm has yet to generate fusion reactions, but nevertheless aims to put electricity into the grid by 2030 - using a reactor perhaps 100 times smaller than ITER.

"We see fusion as a series of very substantial engineering challenges," says the company's chief executive David Kingham. "The physics doesn't have to be perfectly understood."

Federici agrees that engineering is now key to building working fusion plants. But he is sceptical that the newer, cut-price proposals will do the job, arguing that they face daunting design challenges.

"Cheap, fast and small is something that fusion will never be," he says.

2. MIT Achieves Breakthrough in Nuclear Fusion

New experiments with helium-3 in a magnetic confinement tokamak have produced exciting results for the future of fusion energy, including a tenfold increase in ion energy.

By Jay Bennett

Aug 28, 2017

http://www.popularmechanics.com/science/energy/a27961/mit-nuclear-fusion-experiment-increases-efficiency/

Researchers operating fusion reactor experiments at MIT, along with partnered scientists in Brussels and the U.K., have developed a new type of nuclear fusion fuel that produces ten times as much energy from energized ions as previously achieved. The experiments with the new fusion fuel, which contains three types of ions—particles with an electric charge due to the loss or gain of an electron—were conducted in MIT's Alcator C-Mod tokamak, a magnetic confinement reactor that holds the records for highest magnetic field strength and highest plasma pressure in a fusion experiment.

The Alcator C-Mod conducted its final run in September 2016, but data from experiments in the tokamak device were recently analyzed, revealing a unique type of nuclear fusion fuel greatly increases ion energies within the plasma. The results were so encouraging that researchers operating the Joint European Torus (JET) in Oxfordshire, U.K., the largest operational magnetic confinement fusion experiment in the world, repeated the experiments and achieved the same increases in energy generation. A study detailing the findings was recently published in *Nature Physics*.

The key to increasing the efficiency of the nuclear fuel was to add in trace amounts of helium-3, a stable isotope of helium that only has one neutron rather than two. The nuclear fuel used in the Alcator C-Mod previously contained just two types of ions, deuterium and hydrogen. Deuterium, a stable isotope of hydrogen with one neutron in its nucleus—compared to common hydrogen which has no neutrons—accounts for about 95 percent of the fuel.

While industrial magnets suspend the fuel and hold it in place, the researchers at MIT's Plasma Science and Fusion Center (PSFC) used a process called radio-frequency heating to ignite the nuclear fuel. Antennas outside the tokamak use a specific frequency of radio waves to excite the particles. The radio waves are calibrated to target just the less abundant material, in this case hydrogen ions. Because the hydrogen accounts for a small fraction of the fuel's total density, focusing the radio-frequency heating on the minority ions allows them to reach extreme energy levels. The excited hydrogen ions then slam into the more abundant deuterium ions, and resulting particles fly into the reactor's outer shell, generating heat and electricity.

Researchers improved the efficiency of this process by adding helium-3 ions to the mix. The new fuel contains less than one percent helium-3. By focusing all the radio-frequency heating on this trace amount of helium-3, the researchers raised the ions to megaelectronvolt (MeV) energies. An electronvolt is the amount of energy gained or lost when a single electron jumps from a point of electric potential to a point one volt higher, a common unit of measurement for fusion experiments. The new results with helium-3 fuel, generating ions that reach megaelectronvolt energies, has never been achieved before, and the increase in ion energy is a full order of magnitude higher than previous efforts.

The Alcator C-Mod and JET are nuclear fusion experiments with the the capability to reach the same plasma pressures and temperatures that would be required in a full-scale fusion reactor, though they are smaller and do not produce what researchers call "activated fusion"—fusion from which energy is actually converted into power for use. Tweaking the fuel composition, radio wave heating frequencies, magnetic fields, and other variables in these fusion experiments allows researchers to dial in the most efficient fusion process possible before attempting the reaction on an industrial scale.

"These higher energy ranges are in the same range as activated fusion products," said MIT fusion research scientist John C. Wright. "To be able to create such energetic ions in a non-activated device—not doing a huge amount of fusion—is beneficial, because we can study how ions with energies comparable to fusion reaction products behave, how well they would be confined

The MIT data from the Alcator C-Mod encouraged nuclear fusion researchers at JET to conduct experiments with the same type of fusion fuel. Not only did the British researchers at JET achieve the same results, but the two fusion experiments were able to measure different properties of the incredibly complex reactions occurring in the superheated plasma. At MIT, fusion scientists used a process known as phase contrast imaging (PCI) to accurately measure interactions between the fuel particles and the radio waves, while the JET scientists had the capability to more precisely measure the energy of MeV particles. The resulting picture of what happens during the fusion reactions is more complete than either facility could have achieved on its own.

"The JET folks had really good energetic particle diagnostics, so they could directly measure these high energy ions and verify that they were indeed there," says Wright. "The fact that we had a basic theory realized on two different devices on two continents came together to produce a strong paper."

Nuclear fusion has the potential to revolutionize energy production, with virtually endless power available from common elements like hydrogen and helium and no dangerous waste products produced as a result. Experiments like the Alcator C-Mod and JET inch us closer and closer to cracking the code, using the right fuel, and producing the conditions to spark a full-scale, energy-positive fusion reaction.

As the paper in *Nature* notes, the findings from these experiments could also help astronomers better understand helium-3 abundant solar flares that erupt from the sun, because that is literally what these fusion researchers are trying to do—ignite nuclear fusion in plasma that is hundreds of millions of degrees, similar to what stars are made of, trap it, and then power the world with the resulting energy.

Source: MIT

3. Google's Nuclear Fusion Project Is Paying Off

The researchers netted a 50 percent reduction in energy loss, taking us one step closer to a future of unlimited clean energy.

By Jay Bennett
Jul 26, 2017
http://www.popularmechanics.com/science/green-tech/news/a27484/google-fusion-energy-company-improve-plasma-reactor-ai/

Nuclear fusion, the process the sun has used for billions of years to fuse atoms of hydrogen into atoms of helium, could be the pot of gold at the end of the clean energy rainbow. If we could engineer a reaction to snowball but remain contained, nuclear fusion reactors could supply virtually unlimited clean energy here on Earth. Yet, the technology seems perpetually just around the corner.

Google and nuclear fusion company Tri Alpha Energy, which operates fusion reactor projects in California, just took us one step closer to rounding that corner. The two companies began working together in 2014, and they just released their first major research results. Google and Tri Alpha Energy developed a new process to sift through the enormous amounts of data that detail plasma's behavior in fusion reactors. The process involves humans who input preferences into an advanced Google machine learning algorithm, and so far the system has successfully achieved a 50 percent reduction in energy loss. The results were recently published in the journal *Scientific Reports*.

Tri Alpha's plasma generators use magnetic confinement, meaning they trap the plasma that is to undergo fusion using a magnetic field, but it is unique from other magnetic confinement reactors such as tokamak reactors. The Tri Alpha reactors use what is known as a field-reversed configuration, which takes advantage of eddy currents in the plasma itself to reverse the magnetic field, rather than relying entirely on external magnetic coils on the machine. The result is a self-stabilized, rotating cylinder of particles held in place by magnetism, similar in structure to a smoke ring. The major advantage to this technique is that as the energy of the plasma grows higher, the magnetic confinement gets stronger and more stable as a response.

Creating this magnetic field-reversed configuration and maintaining it by injecting protons, electrons, and boron fuel into the reactor is incredibly complicated. The number of variables is almost endless, which is why Tri Alpha Energy looked to Google for computing help in the first place. But even Google's renowned supercomputers couldn't handle the job.

"The reality is much more complicated," said Ted Baltz of Google's Accelerated Science Team. "The ion temperature is three times larger than the electron temperature, so the plasma is far out of thermal equilibrium. Also, the fluid approximation is totally invalid, so you have to track at least some of the trillion plus individual particles, so the whole thing is beyond what we know how to do even with Google-scale computer resources."

The solution was to input some human deduction back into the problem, something the team is calling an "Optometrist Algorithm." The number of variables to account for is simply too high, so human plasma technicians told the computer what specific behaviors to look for. If the particles are acting weird in a specific way, or the magnetic field at large is losing strength, the computer can be programed to sift through the data and search for just the relevant causes.

"We boiled the problem down to 'let's find plasma behaviours that an expert human plasma physicist thinks are interesting, and let's not break the machine when we're doing it'," said Baltz. "This was a classic case of humans and computers doing a better job together than either could have separately."

To further the study of nuclear fusion even more, Tri Alpha Energy built a new, larger plasma generator. The machine, called "Norman" after the late co-founder of Tri Alpha Energy, Norman Rostoker, heats plasma with a beam of high-energy neutral particles, a process known as neutral beam injection, and traps the plasma with a field-reversed configuration.

A 50 percent reduction in energy loss is huge, and the improved magnetic system generates more ion heat and plasma energy to begin with as well. We can trap plasma and spark nuclear fusion in a lab today, but the reaction requires more energy input than it releases. With advances in efficiency from data scouring processes like Google and Tri Alpha's "Optometrist Algorithms," it's possible we actually see an energy-positive fusion reactor constructed in the coming years.

How expensive the infrastructure will be, and whether or not nuclear fusion will usher in a brave new world of unlimited power, is yet to be seen.

Sources: Tri Alpha Energy, Google Research Blog

4. The US, China and Russia are working on a fusion project which could transform energy

Anmar Frangoul

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https://www.cnbc.com/2017/08/24/the-us-china-russia-working-on-fusion-project-transform-energy.html

At a research facility in the south of France, 35 countries, including the U.S., China and Russia, are working together on a project that could transform the way we think about energy.

Known as ITER – an acronym for the International Thermonuclear Experimental Reactor as well as Latin for 'the way' – the collaboration is constructing a magnetic fusion device known as a tokamak.

The ambition for the project is big. The tokamak has been designed to prove that fusion is a feasible large scale, carbon-free source of energy based on the same – and slightly mind boggling – principle which powers our Sun.

The difference between fission, which is used to produce nuclear energy today, and fusion is significant.

"Fission is taking a very large atom like uranium, you hit it and it splits it apart into two pieces," Mark Henderson, a physicist at ITER, told CNBC's Sustainable Energy. "Fusion takes… two (very) small particles, it fuses together and give(s) off energy," he added.

The potential of fusion is huge. According to the World Nuclear Association, fusion power "offers the prospect of an almost inexhaustible source of energy for future generations."

Henderson said that the Sun was around 15 million degrees Celsius, and that the aim at ITER's tokamak was to generate 150 million degrees Celsius.

"The objective there is (that) you need it to be really hot to take two charged particles and slam them together to fuse," he said. "The two charged particles are both positive. Normally they don't want to touch and you have to give them the energy so that they can actually combine and fuse together."

The ITER facility is currently under construction. European Union countries are responsible for the largest portion of costs, with the remainder shared by China, India, Japan, South Korea, the U.S. and Russia.

When it is up and running, those behind the project say that it will be the first fusion device to generate "net energy". This term, according to ITER, refers to what happens when the total energy produced during a fusion plasma pulse exceeds the amount of energy needed to power the machine's systems.

This concept of "net energy" is an exciting, tantalizing one. Is fusion, though, just a pipe dream?

"ITER is our countries coming together to answer that question once and for all: can fusion play a role in the future," William D. Magwood IV, director general of the OECD's Nuclear Energy Agency, said.

Magwood IV added that once it was operating, the tests performed at ITER would help to answer that question.

Anmar FrangoulFreelance Digital Reporter, CNBC.com

5. The Nuclear Tech Breakthrough That Could Make Oil Obsolete

August 22, 2017 — 4:57 AM SGT

https://www.bloomberg.com/news/audio/2017-08-21/the-nuclear-tech-breakthrough-that-could-make-oil-obsolete

We hear a lot about the approaching end of the fossil fuel era. But as various companies work on wind and solar, there's a group of scientists quietly working on another method of generating electricity, in the lab that once created the atomic bomb. This week, Bloomberg Technology's Jing Cao visits the researchers who are smashing hydrogen atoms together in a process called nuclear fusion. They say they're on the brink of a major milestone, but they face an age-old problem: not enough funding.

Bloomberg Radio +1-212-617-5560

6. Physicists propose new way to stabilize next-generation fusion plasmas

By
Raphael Rosen
September 11, 2017
http://www.pppl.gov/news/2017/09/physicists-propose-new-way-stabilize-next-generation-fusion-plasmas

A key issue for next-generation fusion reactors is the possible impact of many unstable Alfvén eigenmodes, wave-like disturbances produced by the fusion reactions that ripple through the plasma in doughnut-shaped fusion facilities called "tokamaks." Deuterium and tritium fuel react when heated to temperatures near 100 million degrees Celsius, producing high-energy helium ions called alpha particles that heat the plasma and sustain the fusion reactions.

These alpha particles are even hotter than the fuel and have so much energy that they can drive Alfvén eigenmodes that allow the particles to escape from the reaction chamber before they can heat the plasma. Understanding these waves and how they help alpha particles escape is a key research topic in fusion science.

If only one or two of these waves are excited in the reaction chamber, the effect on the alpha particles and their ability to heat the fuel is limited. However, theorists have predicted for some time that if many of these waves are excited, they can collectively throw out a lot of alpha particles, endangering the reactor chamber walls and the efficient heating of the fuel.

Recent experiments conducted on the DIII-D National Fusion Facility, which General Atomics operates for the U.S. Department of Energy (DOE) in San Diego, have revealed evidence that confirms these theoretical predictions. Losses of up to 40 percent of high-energy particles are observed in experiments when many Alfvén waves are excited by deuterium beam ions used to simulate alpha particles and higher-energy beam ions in a fusion reactor such as ITER, which is now under construction in the south of France.

In the wake of this research, physicists at the DOE's Princeton Plasma Physics Laboratory (PPPL) produced a quantitatively accurate model of the impact of these Alfvén waves on high-energy deuterium beams in the DIII-D tokamak. They used simulation codes called NOVA and ORBIT to predict which Alfvén waves would be excited and their effect on the confinement of the high-energy particles.

The researchers confirmed the NOVA modeling prediction that over 10 unstable Alfvén waves can be excited by the deuterium beams in the DIII-D experiment. Furthermore, in quantitative agreement with the experimental results, the modeling predicted that up to 40 percent of the energetic particles would be lost. The modeling demonstrated for the first time, in this type of high-performance plasma, that quantitatively accurate predictions can be made for the effect of multiple Alfvén waves on the confinement of energetic particles in the DIII-D tokamak.

"Our team confirmed that we can quantitatively predict the conditions where the fusion alpha particles can be lost from the plasma based on the results obtained from the modeling of the DIII-D experiments" said Gerrit Kramer, a PPPL research physicist and lead author of a paper that describes the modeling results in the May issue of the journal *Nuclear Fusion*.

The joint findings marked a potentially large advance in comprehension of the process. "These results show that we now have a strong understanding of the individual waves excited by the energetic particles and how these waves work together to expel energetic particles from the plasma," said physicist Raffi Nazikian, head of the ITER and Tokamaks Department at PPPL and leader of the laboratory's collaboration with DIII-D.

The NOVA+ORBIT model further indicated that certain plasma conditions could dramatically reduce the number of Alfvén waves and hence lower the energetic-particle losses. Such waves and the losses they produce could be minimized if the electric current profile in the center of the plasma could be broadened, according to the analysis presented in the scientific article.

Experiments to test these ideas for reducing energetic particle losses will be conducted in a following research campaign on DIII-D. "New upgrades to the DIII-D facility will allow for the exploration of improved plasma conditions," Nazikian said. "New experiments are proposed to access conditions predicted by the theory to reduce energetic particle losses, with important implications for the optimal design of future reactors."

The DOE Office of Science supported this research. Members of the research team contributing to the published article included scientists from PPPL, General Atomics, Lawrence Livermore National Laboratory and the University of California, Irvine.

PPPL, on Princeton University's Forrestal Campus in Plainsboro, N.J., is devoted to creating new knowledge about the physics of plasmas — ultra-hot, charged gases — and to developing practical solutions for the creation of fusion energy. The Laboratory is managed by the University for the U.S. Department of Energy's Office of Science, which is the largest single supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time. For more information, please visit science.energy.gov

7. Rosatom head visits Iter, latest equipment batch sent

12 September 2017

Rosatom Director-General Alexey Likhachov yesterday visited the construction site of the International Thermonuclear Experimental Reactor (Iter), which the Russian state nuclear corporation said has now entered the "full-scale practical implementation phase". Rosatom also announced that it has sent the latest batch of six trailers with high-current busbars for the power supply systems of Iter's superconducting magnet.

http://www.world-nuclear-news.org/NN-Rosatom-head-visits-Iter-latest-equipment-batch-sent-12091701.html

Under construction in Cadarache, France, Iter is the world's biggest tokamak - a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers the Sun and stars. A total of 35 countries, including 29 European Union member-states, as well as China, India, Japan, Russia, South Korea and the USA, are participating in the Iter project. The launch of the reactor and production of the first batch of plasma is scheduled for 2025.

Russian companies are developing more than 25 "unique systems" for Iter, including superconductors, gyrotrons, and protection and diagnostic equipment, Rosatom said.

Likhachov visited Iter at the invitation of ITER Organisation Director-General Bernard Bigot, who said: "Russia has always been an exemplary partner, which meets all its obligations in full and on time."
Likhachov noted that progress with Iter is visible not only on the construction site, but also in the production and supply of components.
He said: "The exploration of thermonuclear fusion energy will open up vast scientific and technological prospects for mankind. That is why Russia, which has unique experience in nuclear and thermonuclear research, is now at the forefront of the Iter project and is making a fundamental contribution to its implementation. It is also important to note that the very concept of this international project, namely tokamak, was developed in our country."
In 1950, Russian academicians Andrei Sakharov and Igor Tamm suggested using magnetic field for plasma confinement. Later, Russian scientists under the direction of academician Lev Artsymovich developed and used the concept of thermonuclear facility - Tokamak (Toroidal Chamber Magnetic Coil), which later became the world leader in the controlled thermonuclear fusion research. This facility is assumed as the basis of the Iter thermonuclear reactor.
Likhachov added: "Iter is important for us as a testing ground for practical tasks related to the energy of the future, with the increasing role of Russia on the global technology market."
During his visit to Cadarache, Likhachov also met with the chairman of the French Alternative Energies and Atomic Energy Commission, Daniel Verwaerde, with whom he visited the construction site of the Jules Horowitz Reactor. This is an international project to build a 100 MWt material testing reactor.

Equipment

The latest consignment of Russian equipment for Iter has a total weight of about 85 tonnes and includes: aluminum water-cooled direct-current buses for the poloidal field, the central solenoid and correcting winding power systems; thermal expansion joints and other parts of the DC bus systems that connect the superconducting windings of the tokamak electromagnetic system with their power supply sources; as well as sections of operational resistors for plasma discharge initiation systems.
"To date, this is the third - and the largest - supply of electrical equipment for the Iter reactor," Rosatom said. The first two batches of busbar elements for power supply to Iter's superconducting were sent from Saint Petersburg in 2015-2016.

The consignment has been sent to the seaport of Saint Petersburg for further transportation to the site of the reactor in Cadarache, via Hamburg, Germany.
Switchgear equipment, busbars and power-absorbing resistors for power supply and protection of Iter's superconducting magnet system are manufactured by the D V Efremov Scientific Research Institute of Electrophysical Apparatus in Saint Petersburg.
The Iter magnet system comprises 18 superconducting toroidal field and six poloidal field coils, a central solenoid, and a set of correction coils that magnetically confine, shape and control the plasma inside the vacuum vessel. The poloidal field (PF) magnets pinch the plasma away from the walls and contribute in this way to maintaining the plasma's shape and stability. The PF is induced both by the magnets and by the current drive in the plasma itself.

Researched and written
by World Nuclear News

8. Australia becomes active member of GIF

18 September 2017

Australia has formally acceded to the Framework Agreement of the Generation IV International Forum (GIF), an international task force set up to develop and design the next generation of nuclear energy systems. Accession allows Australia, which has no nuclear power program of its own, to become actively engaged in R&D projects related to Generation IV systems.

http://www.world-nuclear-news.org/NN-Australia-becomes-active-member-of-GIF-1809178.html

Australia became the 14th member of the GIF in June 2016 when the Australian Nuclear Science and Technology Organisation (Ansto) signed the GIF Charter. It deposited its instrument of accession to the Framework Agreement on 14 September and was officially welcomed to the organisation at a ceremony in Paris.
The GIF - a cooperative international endeavour to develop and design the next generation of nuclear energy systems - was founded in 2001 by Argentina, Brazil, Canada, France, Japan, South Africa, South Korea, the UK and the USA. Switzerland joined in 2002, Euratom in 2003, and China and Russia in 2006, followed by Australia in 2016.

The GIF Framework Agreement was established in 2005. Its parties are formally committed to participate in the development of one or more so-called Generation IV systems selected by GIF for further R&D. Australia is now the 11th party to accede to the agreement: Argentina, Brazil and the UK are not parties to the agreement and are classed as non-active members of the GIF, although the UK currently participates in GIF activities through Euratom.

Ansto CEO Adi Paterson said the Framework Agreement would enable Australia to contribute to the development of the "international energy systems of the future". Participation in the GIF was an "affirmation of Australia's exemplary research capabilities and STEM [science, technology, engineering, mathematics] industry, strengthened by Ansto's expertise and highly developed nuclear science infrastructure", he said.

Paterson said Ansto would "leverage its world-class capabilities", particularly in relation to advanced materials with applications in extreme industrial environments, and nuclear safety cases.

Members of the GIF are working collaboratively to develop nuclear energy systems which will use fuel more efficiently, produce less waste, and be more economically competitive than previous systems while meeting stringent standards in relation to safety and non-proliferation. The forum in 2002 selected six reactor technologies which they believe represent the future shape of nuclear energy to be the subject of further development, with expenditure of about $6 billion over 15 years. The six concepts are: gas-cooled fast reactors; lead-cooled fast reactors; molten salt fast reactors; sodium-cooled fast reactors; supercritical water-cooled reactors; and very high temperature gas-cooled reactors.

Researched and written
by World Nuclear News

9. Komarov explains nuclear's role in energy mix

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The perception that renewable energy is cheaper than nuclear power is only "half true", Kirill Komarov, Rosatom's first deputy director-general, said in a televised interview with Ian King, business presenter at *Sky News*, this week. "If you combine all the elements you need to establish connection to the grid for renewables, you need to pay additionally for some backup facilities. If you combine all these you will see that nuclear is still, minimum, twice as cheap as wind and, minimum, three times cheaper than solar," Komarov said.

http://www.world-nuclear-news.org/C-Komarov-explains-nuclears-role-in-energy-mix-18091701.html
The Russian state nuclear corporation itself invests in the development of wind power and "that's why I'm a qualified expert on this and I see that investments in nuclear power are more interesting because it's still cheaper".
The company has an order book worth $133 billion over the next decade, excluding its business in Russia. Asked why Rosatom is successful, Komarov said its main advantage is that it covers the entire nuclear fuel cycle.
"We have everything at our disposal in one company, starting from the mining of uranium up to the decommissioning of nuclear power plants, and, honestly, if we want to execute a project we don't even need partners. We do work with partners in different countries, but we have all the resources internally."
He added: "Secondly, a very important point is that what we are doing abroad is not first-of-a-kind. First, we try and implement all new projects, all new designs, all new technical solutions, in our country, and only afterwards do we go abroad because working in foreign countries is definitely much more difficult than working at home."
Komarov stressed that nuclear technology is safe, reliable and can operate for a minimum of 60 years.
"That's why I believe [nuclear power] can still be a very significant part of the energy balance of each and every country, especially taking in account the decarbonisation goal, which cannot be achieved without nuclear," he said.
Asked about claims of the company's "ties to Kremlin", he said that such speculation is common for any state-run company in any country.
"That's not the point," he said. "We [succeed] because we provide the customer with a reliable solution, referenced and cheap."
Researched and written
by World Nuclear News

10. China's 37th reactor enters commercial operation

18 September 2017
Unit 4 of the Fuqing nuclear power plant in China's Fujian province has completed commissioning tests and now meets the conditions for entering commercial operation, China National Nuclear Corporation (CNNC) announced today.
http://www.world-nuclear-news.org/NN-Chinas-37th-reactor-enters-commercial-operation-1809174.html

At 5.57pm yesterday, the 1087 MWe CPR-1000 unit completed a series of commissioning tests, including a load test run and a test run lasting 168 hours, CNNC said. Although the company must still obtain necessary permits and documentation, the unit can now be considered to be in commercial operation.

First concrete was poured for unit 4 in December 2012 and its dome was put in place in June 2014. The process of loading the 157 fuel assemblies into the reactor core began on 13 June this year and was completed six days later. The unit achieved a sustained chain reaction for the first time on 16 July and was connected to the grid on 29 July.

CNNC's Fuqing plant will eventually house six Chinese-designed pressurised water reactors, the first four being 1087 MWe CPR-1000 units. Units 1 to 3 entered commercial operation in November 2014, October 2015 and October 2016, respectively. So far, the units at Fuqing have generated 38 TWh of electricity, avoiding the consumption of over 12 million tonnes of coal and the emission of about 40 million tonnes of carbon dioxide, according to CNNC.

CNNC now has 17 power reactors in operation, with a combined generating capacity of 14,340 MWe.

China's State Council gave final approval for construction of Fuqing 5 and 6 in mid-April 2015. First concrete was poured for the fifth unit in May 2015, while that for unit 6 was poured in December. These will be demonstration indigenously-designed Hualong One reactors. CNNC expects all six units at Fuqing to be fully commissioned and put into operation in 2021.

The Fuqing nuclear power plant project is owned by CNNC subsidiary China Nuclear Power Company (51%); Huadian Fuxin Energy Company (39%); and Fujian Investment and Development Group (10%).

Researched and written
by World Nuclear News

11. Jobs for two centuries in nuclear

15 September 2017

Some 200,000 job-years of employment are created by each 1000 MWe of nuclear capacity constructed, according to a new study by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA).

http://www.world-nuclear-news.org/NN-Jobs-for-two-centuries-in-nuclear-1509171.html

The figures come from a joint report entitled *Measuring Employment Generated by the Nuclear Power Sector*. The authors used a combination of top-down and bottom-up approaches in an attempt to create a methodology that can be applied to all electricity sources. The report's conclusions were announced today by the NEA's Geoffrey Rothwell at the World Nuclear Association Symposium.

During site preparation and construction of a typical 1000 MWe reactor there are about 12,000 job-years during construction, said Rothwell. Then, for 50 years of operation, annually there are about 600 administrative, operation and maintenance, and permanently contracted staff, or about 30,000 direct job-years during operation. After operation comes decommissioning, for which there are about 500 employees annually over a period of ten years, so about 5000 direct job-years. Finally, for 40 years there are about 80 employees managing radiaoctive waste accounting for about 3000 direct job-years. That puts direct employment from a 1000 MWe nuclear reactor at about 50,000 direct job-years per GWe.

In addition, the study put indirect employment in the nuclear supply chain at another 50,000 job-years. Rothwell said that induced employment to service the from all of the above adds up to another 100,000 job-years. Therefore, the total employment from a 1000 MWe nuclear power reactor is about 200,000 job-years, he said.

The work was done in collaboration with employees at Areva, the Center for Advanced Energy Studies (Idaho, USA), the Generation-IV International Forum secretariat, the Korean Atomic Energy Research Institute (KAERI), the US Nuclear Energy Institute, PriceWaterHouseCoopers Strategy Group, Rosatom Central Institute, and the University of Stuttgart.

Harmony

The workforce to fulfil the Harmony goal of 1000 GWe of new build by 2050 could require peak direct employment of 810,000 job-years per year, said Rothwell. "These are people passing through the gates of the plants," said Rothwell.

"The Harmony program is providing employment until 2160. We are not talking about one century. This is a project for the next two centuries."

Given historically low rates of investment and high rates of unemployment, Rothwell said, "Now is the time to employ short-term and long-term under employed workers in building infrastructure. Nuclear power provides high-skilled, high-pay construction and supply chain jobs to lower unemployment rates and increase average wages."

Local jobs

In a 2010 study by D Harker and P Has Hirschboeck, referenced by Rothwell's presentation, nuclear was found to create 0.50 jobs per MWe of capacity. This is below solar power's 1.06 jobs per MWe, but places nuclear in a favourable group with sub-20 MWe hydro (0.45 jobs per MW), concentrating solar power (0.47 jobs per MWe), and far ahead of wind and combined cycle gas which each yield only 0.05 jobs per MWe. As larger facilities with far higher nameplate capacities, nuclear facilities come out as the largest employers of local people among clean energy sources.

Researched and written
by World Nuclear News

12. 13 September 2017

JT-60SA cryostat vessel body manufacturing and pre-assembly completed

http://fusionforenergy.europa.eu/mediacorner/newsview.aspx?content=1168

The JT-60SA cryostat vessel body has been successfully manufactured and pre-assembled in the Asturfeito S.A. factory located in Aviles, Spain. As a voluntary contributor to the Broader Approach agreement, Spain, through the national fusion research centre CIEMAT, has delivered this component in collaboration with F4E.

The JT-60SA machine is a precursor to ITER: the know-how about optimising plasma operation obtained through the JT-60SA project will be used to develop and benefit ITER.

The cryostat vessel body works as a large containment vessel which will enclose all core JT-60SA components. It consists of 4 individual upper sectors (with a height of around 4 metres) and 8 individual lower sectors (with a height of about 7 metres) which have each been separately positioned and precisely adjusted to form a cylindrical shape which measures about 14 metres in diameter. The cryostat vessel body will provide a thermal insulation and vacuum around the magnet components within the machine in order to ensure that they stay at the cryogenic temperature necessary (at 4 Kelvin) for their superconducting functions. Made of 30 mm single-walled stainless steel, the cryostat vessel body can be likened to a thermos in the sense that together with the thermal shields and suprainsulation (multi-layer insulation) inside its shell, it is able to minimise the energy losses by conduction, convection and irradiation.

Manufacturing and testing of each individual sector has been carried out during four years. Pre-assembly of the sectors while still in the factory is necessary to ensure that the re-assembly at the JT-60SA site in Naka, Japan, runs smoothly and that each of the sectors has the required tolerances. Because all vacuum vessel ports, auxiliary devices, cryolines and supply lines need to be fitted precisely in the 83 different flanges and openings of the cryostat vessel body, it is vital to ensure that all pieces of the sectors fit together. By carrying out the pre-assembly at the factory, it is still possible to carry out adjustments to the components if necessary.

Pre-assembly has been performed in three stages: One by one, the eight lower sectors have been positioned, adjusted and bolted to a supporting system reproducing the cryostat basement in Naka. Later, the four upper sectors have been assembled on a temporary supporting system which lastly has been lifted, positioned, adjusted and then joined on the lower sectors. With pre-assembly and metrology now successfully completed, the sectors are currently being dismantled and will undergo final minor refurbishments to eliminate potential superficial damages that may have occurred during the handling and pre-assembly. After final cleaning and packaging, ownership of the JT-60SA cryostat vessel body will be transferred from Spain to F4E and all sectors will be transported to Naka. All components are expected to arrive in Japan between December 2017 and January 2018 – over a year ahead of the required final assembly date in Naka.

13. 29 August 2017

Europe delivers to ITER the first cryopump

http://fusionforenergy.europa.eu/mediacorner/newsview.aspx?content=1166

F4E's vacuum pumping specialists have celebrated an important milestone together with their counterparts from ITER International Organization: the first cryopump has been successfully manufactured following the specifications of the cryopumps to be used in the torus of the machine and cryostat. The component has been delivered on-site and will go through a series of tests. F4E has been responsible for the procurement of this component, which took roughly four years to be manufactured and reached a cost of approximately 3 M EUR.

Research Instruments, Alsyom and SDMS are some of the companies that have contributed to this technical achievement with the support of their subcontractors. The equipment which measures 3.4 x 1.8 m and weighs close to 8 T, has been developed in different stages and has been progressively assembled.

After the performance testing of this cryopump is successfully completed, eight more will be manufactured under the supervision of F4E. Six of them will be installed in the torus of the ITER device and two in the cryostat. When ITER is operational, the gases resulting from the fusion reaction will be pumped with the help of the six cryopumps from the lower part of the torus to the roughing system, where they will be processed and treated in a closed loop as part of the fuel cycle. Europe is the only party responsible for the production of the cryopumps. The successful completion of the first one will help towards the finalisation of the design of the reaming eight, which are expected to be delivered in 2022.

14. 16 August 2017

F4E Director strengthens ties with Chinese ITER colleagues

http://fusionforenergy.europa.eu/mediacorner/newsview.aspx?content=1165

The success of ITER depends on a strong partnership between Europe and the six other countries involved in the project. To this end, F4E's Director, Johannes Schwemmer, accepted an invitation to visit the Chinese ITER Domestic Agency and two major fusion research organisations at the end of July. The status of EU ITER contributions contracted to China was also reviewed, and the visit served to improve the mutual understanding of the organisation of ITER work and explore areas for deeper collaboration in the future.

To begin the visit, productive meetings took place in Beijing with the Head of the Chinese ITER Domestic Agency(CNDA), Professor Delong Luo, and other senior managers from CNDA, which is part of the Ministry of Science and Technology. The participants reviewed the progress of the shared ITER work as well as the status of the work CN DA does for F4E.. Interesting exchanges took place on the organisation of ITER work in Europe and China and possible areas for deeper collaboration in the future.

Leaving Beijing, Johannes Schwemmer visited the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in Hefei.He played an official part in the celebration proceedings for the completion of the first of 31 feeders for the ITER Poloidal Field coils. This is the first ITER magnet component to be completed. During the visit, Professor Yuntao Song, the Deputy Director General of ASIPP, provided a tour of the factory that produces the ITER Toroidal and Poloidal field conductors, as well as of the ITER magnet power supplies test facility. Johannes Schwemmer also visited the factory where ASIPP is manufacturing the 18 superconducting correction coils which will reduce imperfections in ITER's magnetic field. Last but not least he showed the EAST Tokamak – which achieved the major milestone of a 100 s long H-mode plasma just a month earlier.

F4E is responsible for five of the Poloidal Field coils (PF2-PF6) and Russia for one (PF1). Due to their impressive diameter and weight, F4E manufactures PF2-PF5 at the ITER site. ASIPP manufactures the remaining one (PF6) in China through a collaboration agreement between F4E and ASIPP. During his visit Johannes Schwemmer took the opportunity to tour the PF6 coil workshop to see all stages of the coil fabrication from the winding to the impregnation and meet the F4E team. Mr Schwemmer congratulated the Chinese colleagues on meeting the main milestones, in particular, the qualification work and the winding of the dummy double pancake as well as the excellent working relationship between F4E and ASIPP. Building on the good progress achieved, all participants agreed on the importance of maintaining the manufacturing schedule.

To conclude his visit to China, The F4E Director travelled to the Southwestern Institute of Physics (SWIP) in Chengdu. SWIP, like ASIPP, is providing important contributions to the ITER project as well as running fusion research experiments. Professor Xuru Duan, Deputy Director of SWIP, welcomed Johannes Schwemmer and provided a tour of the HL-2A tokamakwhich focuses on research in advanced divertor concepts. Mr Schwemmer also toured the First Wall R&D facility run by SWIP which is well-advanced with developing the production line for the enhanced heat flux panels for theblanket inside the ITER vesselfollowing the successful completion of the stringent ITER qualification programme.

The F4E Director's visit to China served to improve the mutual understanding of the European and Chinese fusion programmes among the two Domestic Agencies and the organisation of ITER in particular. It was an opportunity to acknowledge progress and support, especially for the production of PF6, to learn and exchange views, and ultimately to strengthen collaboration. "I was very impressed by the progress made by China in its contributions to ITER and the far-sighted vision for future fusion energy development. I am personally grateful to our Chinese hosts for the time they devoted to our visit and their warm hospitality which greatly exceeded our expectations," said Johannes Schwemmer.