ITER Forum website Update 4/16

B.J.Green (17/4/16)

1. Convergence in the temperature response of leaf respiration across biomes and plant functional types

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Edited by William J. Bond, University of Cape Town, Cape Town, South Africa, and approved February 18, 2016 (received for review October 13, 2015)

http://www.pnas.org/content/early/2016/03/16/1520282113.abstract

Significance

A major concern for terrestrial biosphere models is accounting for the temperature response of leaf respiration at regional/global scales. Most biosphere models incorrectly assume that respiration increases exponentially with rising temperature, with profound effects for predicted ecosystem carbon exchange. Based on a study of 231 species in 7 biomes, we find that the rise in respiration with temperature can be generalized across biomes and plant types, with temperature sensitivity declining as leaves warm. This finding indicates universally conserved controls on the temperature sensitivity of leaf metabolism. Accounting for the temperature function markedly lowers simulated respiration rates in cold biomes, which has important consequences for estimates of carbon storage in vegetation, predicted concentrations of atmospheric carbon dioxide, and future surface temperatures.

Abstract

Plant respiration constitutes a massive carbon flux to the atmosphere, and a major control on the evolution of the global carbon cycle. It therefore has the potential to modulate levels of climate change due to the human burning of fossil fuels. Neither current physiological nor terrestrial biosphere models adequately describe its short-term temperature response, and even minor differences in the shape of the response curve can significantly impact estimates of ecosystem carbon release and/or storage. Given this, it is critical to establish whether there are predictable patterns in the shape of the respiration–temperature response curve, and thus in the intrinsic temperature sensitivity of respiration across the globe. Analyzing measurements in a comprehensive database for 231 species spanning 7 biomes, we demonstrate that temperature-dependent increases in leaf respiration do not follow a commonly used exponential function. Instead, we find a decelerating function as leaves warm, reflecting a declining sensitivity to higher temperatures that is remarkably uniform across all biomes and plant functional types. Such convergence in the temperature sensitivity of leaf respiration suggests that there are universally applicable controls on the temperature response of plant energy metabolism, such that a single new function can predict the temperature dependence of leaf respiration for global vegetation. This simple function enables straightforward description of plant respiration in the land-surface components of coupled earth system models. Our cross-biome analyses shows significant implications for such fluxes in cold climates, generally projecting lower values compared with previous estimates.

Footnotes

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Author contributions: M.A.H., O.S.O., M.G.T., and O.K.A. designed research; M.A.H., O.S.O., M.G.T., L.K.W., A.P., J.J.G.E., D.C., K.J.B., J.X., F.S., Z.R.S., A.M.-d.l.T., K.L.G., C.H., V.H., M.H.T., and O.K.A. performed research; M.A.H., O.S.O., P.B.R., M.G.T., L.K.W., A.P., J.J.G.E., D.C., K.J.B., J.X., A.M.-d.l.T., K.L.G., C.H., V.H., P.M., M.H.T., and O.K.A. analyzed data; and M.A.H., O.S.O., P.B.R., M.G.T., A.M.-d.l.T., C.H., and O.K.A. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1520282113/-/DCSupplemental.

2. The Opinion Pages | OP-ED CONTRIBUTOR

What Weather Is the Fault of Climate Change?

By HEIDI CULLENMARCH 11, 2016

http://www.nytimes.com/2016/03/11/opinion/what-weather-is-the-fault-of-climate-change.html?_r=0

LIKE politics, weather can be a contentious subject, especially when you throw climate change into the mix. One view holds that no single storm or drought can be linked to climate change. The other argues that all such things are, in some sense, "caused" by climate change, because we have fundamentally altered the global climate and all the weather in it.

While true, this "all in" philosophy doesn't adequately emphasize the fact that not all of the extreme weather we experience today has changed significantly. Some of it is just, well, the weather.

But some of our weather *has* changed significantly, and now a new report from the National Academies of Sciences, Engineering and Medicine has outlined a rigorous, defensible, science-based system of extreme weather attribution to determine which events are tied to climate change.

Like the surgeon general's 1964 report connecting smoking to lung cancer, the report from the National Academies connects global warming to the increased risk and severity of certain classes of extreme weather, including some heat waves, floods and drought.

This is an important development. Climate change can no longer be viewed as a distant threat that may disrupt the lives of our grandchildren, but one that may be singled out as a factor, possibly a critical factor, in the storm that flooded your house last week. The science of extreme weather attribution brings climate change to our doorsteps.

Understanding how climate change is affecting extreme weather is critical for insurers, policy makers, engineers and emergency managers as they assess risk and figure out how to make communities more resilient. This knowledge can help to steer decisions on where and how to build or rebuild after a storm or flood, or whether to build or rebuild at all.

And those are decisions we're going to face with increasing frequency as the planet continues to warm. Scientists are now able to assess, in some cases within days, whether and how much the risk of such an extreme weather event has changed compared to the past — that is, before heat-trapping greenhouse gases altered our climate. This knowledge will help communities make decisions appropriate for today's risks. These can include storm surge risk maps that reflect sea-level rise, better water management to reduce the effects of longer and more intense droughts, and improved floodplain management in increasingly flood-prone areas.

Climate change brings with it many existential threats — rising seas, acidifying oceans, species extinction. But the most immediate and costly threats result from the changing risks of extreme weather. Our perception of these risks has been almost entirely based on the past. That's how insurance companies have assessed our premiums. But if weather risks change, and events that used to have a 1-in-500 chance of happening in any given year now have a 1-in-50 chance, insurance premiums will rise or insurance itself might become unavailable.

Here's an example that underscores the predictive power of extreme event attribution: A recently published study in the journal Nature Climate Change analyzed record-breaking rains in Britain that flooded thousands of homes and businesses and caused more than $700 million in damage in the winter of 2013-14. Scientists found that such an event had become about 40 percent more likely. As a result, roughly 1,000 more properties are now at risk of flooding, with potential damage of about $40 million.

Climate change is, of course, never the only player in a so-called *natural* disaster. Many other natural and human factors are at play. Countless communities are vulnerable because of limited resources and poor infrastructure. Certain classes of extreme events will be relatively straightforward to dissect and attribute (heat waves, heavy rains, certain types of drought) while others are at the far edge of what science can now understand (tornadoes, wildfires and the frequency and intensity of hurricanes).

Heat waves, for example, are expected to become more common, intense and longer because of the increase in heat-trapping gases in the atmosphere. One recent study found that an extreme heat wave last May in Australia was made 23 times more likely because of climate change. When the numbers get that big, it’s fair to say that some episodes of extreme heat would have been *virtually impossible* (but never absolutely impossible) without climate change.

Drought is more complicated because of the multiple factors — temperature, precipitation, soil moisture, snowpack levels — involved. The California drought is an example of this complexity. While we now know that higher temperatures resulting from global warming are worsening the drought, current evidence indicates that the lack of precipitation in the state is not primarily a result of climate change.

Without the rigorous methodologies outlined in the National Academies report, we run the risk of attributing extreme weather to climate change based on sheer conjecture or political bias.

And sometimes it is easier to blame climate change than acknowledge inaction in the face of factors unrelated to the weather. For example, in a severe drought plaguing southeastern Brazil — including São Paulo, with a surrounding metropolitan population of about 20 million — some were quick to blame global warming. But in analyzing the underlying causes of this drought, my colleagues and I found, in a study published last year, that climate change was not a major influence. Instead, population growth, increasing water consumption and leaky pipes were the real culprits.

Science is giving us an increasingly clear picture of how global warming is changing the weather. Still greater investment in research is needed to ensure that we're making the best possible decisions to protect our communities. We may not always like what we learn, but we can be certain that unless we take immediate action to slow climate change, its influence on our lives will only intensify.

Heidi Cullen is chief scientist at Climate Central, a climate research and communications organization, and the author of "The Weather of the Future."

3. Why Nuclear Fusion Is Always 30 Years Away

By Nathaniel Scharping |March 23, 2016 11:50 am

http://blogs.discovermagazine.com/crux/2016/03/23/nuclear-fusion-reactor-research/#.VvohUGNYlYh

Nuclear fusion has long been considered the "holy grail" of energy research. It represents a nearly limitless source of energy that is clean, safe and self-sustaining. Ever since its existence was first theorized in the 1920s by English physicist Arthur Eddington, nuclear fusion has captured the imaginations of scientists and science-fiction writers alike.

Fusion, at its core, is a simple concept. Take two hydrogen isotopes and smash them together with overwhelming force. The two atoms overcome their natural repulsion and fuse, yielding a reaction that produces an enormous amount of energy.

But a big payoff requires an equally large investment, and for decades we have wrestled with the problem of energizing and holding on to the hydrogen fuel as it reaches temperatures in excess of 150 million degrees Fahrenheit. To date, the most successful fusion experiments have succeeded in heating plasma to over 900 million degrees Fahrenheit, and held onto a plasma for three and a half minutes, although not at the same time, and with different reactors.

The most recent advancements have come from Germany, where the Wendelstein 7-X reactor recently came online with a successful test run reaching almost 180 million degrees, and China, where the EAST reactor sustained a fusion plasma for 102 seconds, although at lower temperatures.

Still, even with these steps forward, researchers have said for decades that we're still 30 years away from a working fusion reactor. Even as scientists take steps toward their holy grail, it becomes ever more clear that we don't even yet know what we don't know.

For Every Answer, More Questions

The Wendelstein 7-X and EAST reactor experiments were dubbed "breakthroughs," which is an adjective commonly applied to fusion experiments. Exciting as these examples may be, when considered within the scale of the problem, they are only baby steps. It is clear that it will take more than one, or a dozen, such "breakthroughs" to achieve fusion.

"I don't think we're at that place where we know what we need to do in order to get over the threshold," says Mark Herrmann, director of the National Ignition Facility in California. "We're still learning what the science is. We may have eliminated some perturbations, but if we eliminate those, is there another thing hiding behind them? And there almost certainly is, and we don't know how hard that will be to tackle."

We will almost certainly get a better perspective on the unknown problems facing fusion sometime in the next decade when an internationally-backed reactor, intended to be the largest in the world, comes to fruition. Called ITER, the facility would combine all we have learned about fusion into one reactor.

It represents our current best hope for reliably reaching the break-even point, or the critical temperature and density where fusion reactions produce more power than is used to create them. At the break-even point, the energy given off when two atoms fuse is enough to cause other atoms to fuse together, creating a self-sustaining cycle,

making a fusion power plant possible.
Perhaps inevitably, however, ITER has fallen prey to setbacks and design disputes that have slowed construction. The U.S. has even threatened to cut its funding for the project. It is these sorts of budgetary and policy hesitations that could ensure we continue saying fusion is 30 years away, for the next three decades.
In the face of more immediate challenges, from health epidemics to terrorism, securing funding for a scientific long bet is a hard sell. A decades-long series of "breakthroughs" that lead only to more challenges, compounded by pervasive setbacks, have diluted the fantastic promise of a working fusion reactor.

What Exactly Is Fusion?

Reliably reaching the break-even point is a twofold problem: getting the reaction started and keeping it going. In order to generate power from a fusion reaction, you must first inject it with sufficient energy to catalyze nuclear fusion at a meaningful rate. Once you have crossed this line, the burning plasma must then be contained securely lest it become unstable, causing the reaction to fizzle.
To solve the issue of containment, most devices use powerful magnetic fields to suspend the plasma in midair to prevent the scorching temperatures from melting the reactor walls. Looking something like a giant doughnut, these "magnetic containment devices" house a ring of plasma bound by magnetism where fusion will begin to occur if a high enough temperature is achieved. Russian physicists first proposed the design in the 1950s, although it would be decades before they actually achieved fusion with them.
To create a truly stable plasma with such a device, two magnetic fields are required: one that wraps around the plasma and one that follows it in the direction of the ring. There are currently two types of magnetic confinement devices in use: the tokamak and the stellarator.
The differences between the two are relatively small, but

they could be instrumental in determining their future success. The main disparity in their design arises from how they generate the poloidal magnetic field — the one that wraps around the plasma. Tokamaks generate the field by running a current through the plasma itself, while stellarators use magnets on the outside of the device to create a helix-shaped field that wraps around the plasma. According to Hutch Neilson of the Princeton Plasma Physics Laboratory, stellarators are considered more stable overall, but are more difficult to build and suffer from a lack of research. Tokamaks, on the other hand, are much better understood and easier to build, although they have some inherent instability issues.

At the moment, there is no clear winner in the race between the two, as neither appears to be close to the "holy grail." So, due to lack of a victor, researchers are building both.

"There is a lack of a solution at this time, so looking at two very realistic and promising configurations for closing that gap is the responsible thing to do," says Neilson.

Currently, the largest fusion reactor in the world is the Joint European Torus (JET), a tokamak based in England and supported by the European Union. JET was commissioned in the 1970s and first came online in 1983 and successfully produced plasma, the first step in achieving fusion.

With a series of upgrades beginning in the late 1980s, JET became the world's largest fusion generator, and currently holds the record for the most energy produced in a fusion reaction at 16 megawatts. Even so, it has not yet reached the break-even point.

ITER Offers a Way

To reach this all-important milestone, we will likely have to wait for ITER. Latin for "the way," ITER will be the largest and most powerful fusion generator in the world, and is expected to to cross the break-even point. ITER is projected to produce 500 MW of power with an input of 50 MW, and be able to hold plasma for half an hour or more. That's enough energy to power roughly 50,000 households.

Based on the tokamak design, the project is the result of a collaboration between the European Union and six other countries, including the U.S., that have pooled resources and expertise to build a reactor that is expected to be the gateway to useable fusion energy.

One of the main issues facing current generators is one of size, says Duarte Borba, a researcher at EUROfusion, and ITER will attempt to overcome this shortfall. As reactors get larger, they become more stable and can achieve higher temperatures, the two key factors in creating fusion.

ITER is meant to be the successor to JET, and will take the technology developed there and apply it on a much larger scale. This includes JET's tungsten and beryllium divertors, which capture energy in the reactor, as well as the capability to fully control the system remotely. ITER will also use superconducting magnets to create its magnetic field, as opposed to ones made of copper, according to Borba.

Such magnets will reduce the amount of energy consumed by the device and will allow for longer, more sustained plasma production. JET can currently only produce plasma in bursts, as it cannot sustain the high levels of energy use for very long.

Collaboration Is Key

The most important development made by JET and implemented with ITER may not even be scientific, but rather bureaucratic in nature, says Borba. As a project supported by multiple nations, JET forged the path for organizing and implementing a large-scale, decades-long project.

With a projected price tag of $15 billion and a daunting shopping list of complex components, ITER could only exist today as a collaborative effort. Each of the member nations contributes researchers and components, with the hope that the potential benefits will be shared by all.

However, the democratic nature of ITER has significantly slowed down its construction. The goal is to have all of the parts arrive at the same time, but allocating each part to a different country brings in political and economic variables that throw the timing off. When ITER first received formal approval in 2006, it was slated to first achieve fusion in 2016, a date which has since been pushed back at least 10 years. Issues with component construction and design disagreements have been blamed for the delays.

A Worldwide Effort

To achieve a fusion power plant capable of addressing our energy needs, ITER alone is still not enough, according to Neilson. Even though it represents a significant advancement in reactor design, ITER isn't the end game for fusion research.

If everything goes to plan, ITER will pave the way for another reactor, called DEMO, which will expand the technologies perfected by ITER to an industrial scale, and hopefully prove that nuclear fusion is a viable source of energy.

In the meantime, the new crop of fusion reactors appearing around the world will continue to play crucial roles in the chase for fusion. Far from being redundant, their supplemental research will attack the problem from different angles.

While ITER addresses the issue of scale, fusion projects in Asia are attempting to hold on to plasmas for longer and longer as they probe the benefits of superconducting magnets, Neilson said. Meanwhile, in Germany, the Wendelstein 7-X is pushing the boundaries of the stellarator design, possibly sidestepping issues of stability entirely. Nuclear fusion research has been a mild success in terms of international cooperation, with a growing number of countries determined to contribute their own piece of the puzzle.

Today, there are nuclear fusion experiments operating in the U.S., Germany, United Kingdom, India, France, Japan and several other countries. More reactors are being planned or are currently under construction. Even with the surge of interest, it's still not enough, says Neilson. "For a problem as dense and challenging as fusion, you want to have many more experiments trying out different parts of the problem than we actually have," says Neilson.

More Than a Scientific Problem

Ultimately, the question may be one of funding. Multiple sources said they were confident that their research could progress faster if they received more support. Funding challenges certainly aren't new in scientific research, but nuclear fusion is particularly difficult due to its near-generational timescale. Although the potential benefits are apparent, and would indeed address issues of energy scarcity and environmental change that are relevant today, the day when we see a payoff from fusion research is still far in the future.

Our desire for an immediate return on our investments dampens our enthusiasm for fusion research, says Laban Coblentz, the head of Communication at ITER.

"We want our football coaches to perform in two years or they're out, our politicians have two or four or six years and they're out — there's very little time to return on investment," he said. "So when somebody says we'll have this ready for you in 10 years, that's a tough narrative to tell."

In the U.S., fusion research receives less than $600 million in funding a year, including our contributions to ITER. This is a relatively small sum when compared to the $3 billion the Department of Energy requested for energy research in 2013. Overall, energy research represented 8 percent of the total funding the U.S. gave out for research that year.

"If you look at it in terms of energy budgets, or what's spent on military development, it's not really a lot of money that's going to this," says Thomas Pedersen, division head at the Max-Planck Institut für Plasmaphysik. "If you compare us to other research projects, it seems very expensive, but if you compare it to what goes into oil production or windmills or subsidies for renewables, its much, much less than that."

Pedersen looks at fusion research in terms of expected inputs and gains. Research into solar and wind power may be relatively cheap, but the payoff pales in comparison to a working nuclear fusion generator.

Fusion power is always 30 years away.

However, the finish line has been visible for some time now, a mountaintop that seems to recede with every step forward. It is the path that is obscured, blocked by obstacles that are not only technological, but also political and economic in nature. Coblentz, Neilson and Borba expressed no doubts that fusion is an achievable goal. When we reach it however, may be largely dependent on how much we want it.

Soviet physicist, Lev Artsimovich, the "Father of the Tokamak" may have summed it up best:

"Fusion will be ready when society needs it."

4. China Unveils Plan to Mine the Moon for Helium-3

Manny Salvacion | Apr 02, 2016 11:24 PM EDT

http://en.yibada.com/articles/113421/20160402/china-unveils-plan-mine-the-moon-helium-3.htm

Chinese scientists have announced plans to mine the moon for its rare substance called Helium-3, which is enough to provide energy for nearly 10,000 years and solve the Earth's energy crisis, according to a report by the Huffington Post UK.

According to the report, China's claim was based on tests showing that huge deposits of the substance were found on the moon that can be used as fuel for clean nuclear fusion reactors.

An article published by PBS.org said that China views space as a potential source of energy security and this includes the moon, which has an abundant supply of Helium-3, a light and non-radioactive fusion fuel that cannot be found on Earth.

It is estimated that there are at least 1.1 million metric tons of Helium-3 on the lunar surface to supply human energy needs for up to 10,000 years, the article said.

China is highly aware that it would be a huge strategic advantage if it secures access first to Helium-3, as the U.S., through the Silicon Valley, also expressed interest in it, driven by the $30-million Google Lunar XPRIZE.
For billions of years, solar winds containing Helium-3 bombarded the moon, and since it has no atmosphere, the isotope freely hit its surface and bonded with the dust.
The dusts, which contain Helium-3, can be mined and extracted by heating it to 600 degrees, China claimed. The dust will then be shipped back to Earth where the precious fuel can be extracted.
As a fuel source, Helium-3, considered by scientists to be a "miracle fuel," has many advantages. It is an ideal fuel for clean fusion reactors because it is non-radioactive and can provide a powerful energy source even in small quantities.
It is estimated that 40 tons of the substance could power the entire United States for a whole year, as cited in a report by The Mail Online.
The report said that researchers in the U.S. have started calculating the cost for Helium-3 mining, while China has not announced plans to set up a mining colony on the moon.
Mining Helium-3 is considered an economically viable plan as each ton of the rare substance has an estimated value of $3 billion, while the total R&D cost for building a fusion plant and creating the necessary spacecraft would cost $20 billion.

5. Korea pursues ‘dream energy’ on a ‘Kstar’

Experts worry country is falling behind in nuclear fusion progress

Apr 04,2016

http://koreajoongangdaily.joins.com/news/article/article.aspx?aid=3017027&cloc=joongangdaily%7Chome%7Cnewslist1

Researchers at the National Fusion Research Institute (NFRI) are working on a world-class “Kstar” nuclear fusion reactor that will supply “dream energy” without threatening the environment.

“We set a goal to make energy generated by 300 liters [80 gallons] of coal by just using a liter of seawater in 30 years,” said Oh Young-gook, a deputy chief at Kstar.

Kstar is one of the world's greatest nuclear fusion reactors and is often dubbed "Korea's artificial sun." When it is fully developed, it will be able to make a huge amount of energy, like the sun, through nuclear reaction.

Researchers are working on the superconducting tokamak, the NFRI's facility in Daejeon. It was developed and constructed solely by local technology. Despite the progress, experts are concerned that Korea will fall behind other countries because of a lack of funding.

Nuclear fusion energy is generated when light elements such as hydrogen nuclei make fusion to form helium. Two or more atomic nuclei collide at a very high speed and, during the process, these nuclei are converted to photons, or energy, as they try to repel each other.

Deuterium, or heavy hydrogen, is the only raw material needed to generate energy, and there are unlimited amounts under the sea.

Nuclear fusion energy does not release any nuclear waste, unlike a nuclear power generation.
Due to these unique characteristics, nuclear fusion is often called the "dream energy" that will produce large amounts of energy without affecting global warming or causing environmental damage.

The United States and European countries have been researching the technology since the 1950s. Korea spent 300 billion won ($260 million) in 1995 to create Kstar, and the institute finally began its operations in 2007. Korea was a latecomer to the industry, but its technology has now caught up with other developed countries.

Korea now works with the United States, the European

Union, Russia, Japan and China on the International Thermonuclear Experimental Reactor (ITER), an experimental fusion reactor being built in France. The countries involved will spend some 17.2 trillion won to run the project until 2042. Korea is responsible for 9 percent of the total research funds.
Lee Gyung-su, who ran Kstar in the past, was appointed deputy director general at ITER, and many other Korean researchers are currently participating in the project. Local manufacturers that did businesses with Kstar are also supplying products such as superconducting wire to ITER.

Although many countries are collaborating in developing the experimental reactor, they compete fiercely to get the source technology first.

The European Union has been leading this new industry and is spending tremendous amounts of money, since they believe that the energy will become one of the most important technologies in the future.

The European Union funds 45.6 percent of the total ITER project. Moreover, the European Union plans to spend nearly 4 trillion won until 2018 for Europe’s biggest research and development project, called Horizon 2020’s nuclear fusion sector.

China announced the plan to commercialize the new energy 10 years before other developed countries and is building its own experimental fusion reactor as big as ITER. In addition, 13 Chinese universities and 14 related institutions are researching together on the project.

“China’s nuclear fusion technology will grow faster than Korea’s since the Chinese government is actively involved in it,” said Kim Kee-man, a director general of NFRI.

Japan is also making considerable progress in the industry. The National Institute for Fusion Science (NIFS) and a total of 165 institutions and universities, including Kyoto University, are currently running a joint research project. They have already spent some 132.7 billion won for the fundamental research sector.

Korea is falling behind in research funding. The country invested some 40 billion won in Kstar last year, but other research funds were only about 6.6 billion won. Research institutions such as Seoul National University and the Korea Advanced Institute of Science & Technology are given about 1 billion won each from the fund.

“Korea developed an amazing reactor like Kstar but is not spending much money to follow up or in research and development,” said Hwang Yong-seok, a professor at Seoul National University’s nuclear engineering department.

“Other countries will take away Korea’s key technologies if the government does not give long term and well planned support.”

Another problem Korea is facing is the lack of researchers. It is essential for the country to secure a large number of experts since this new energy sector deals with various kinds of science. The European Union spent some 11.7 billion won a year to educate and train more than 600 graduate students.

In Korea, there are only about 50 people who received masters and doctorate degrees a year. Even though students learn the topic in school, there are not many places that hire them. NFRI recruited only four people last year.

“We need to work hard to find alternatives for energy, such as nuclear fusion, since coal fuel will run out eventually,” said Moon Seung-il, a professor at Seoul National University. “Korea needs to make a long-term plan like China and Japan.”

BY HAM JONG-SUN [kim.youngnam@joongang.co.kr]

6. Fusion for Energy signs €140m contracts

The EU organisation responsible for Europe’s contribution to ITER, Fusion for Energy (F4E), has agreed three separate contracts with two French companies totalling €140m.

http://horizon2020projects.com/global-collaboration/fusion-for-energy-signs-e140m-contracts/
ITER, meaning ‘the way’ – i.e. towards a new energy mix -– activates new commercial opportunities and new markets for those involved in the international project designed to create an experimental fusion reactor. The contracts cover high-tech engineering, frontier R&D and civil construction works, which require a collaboration between suppliers and co-ordination across multiple levels.
Johannes Schwemmer, director of F4E, said: “ITER addresses a wide range of technologies and requires the involvement of companies with a diverse set of skills. Through their participation in this one-of-a-kind project their expertise and confidence will grow further because they will be exposed to some of tomorrow’s industrial challenges.”
Constructions Industrielles de la Méditerranée (CNIM) has been

awarded two contracts, valuing €80m, the first of which is expected to run for four years and the second, seven. A cutting-edge inspection system will be produced, while a combination of high-tech vision and robotics systems will be deployed to carry out inspections inside the ITER machine, which will use powerful superconducting coils to confine the superhot gas at temperatures up to 150,000,000°C.
CNIM's Management Board member Philippe Demigné said: "These contracts highlight the expertise of CNIM in the field of large scientific instruments and the quality of our industrial facilities, which are perfectly suited to large scale projects."
Three subsidiaries of the Spie batignolles Group (Spie batignolles TPCI/Spie batignolles sud-est and Valérian), together with industrial maintenance company ADF, have signed a contract to the value of the remaining €60m to deliver electricity and hydraulic infrastructure services as well as the necessary roadworks infrastructures.
The European Union, thorugh its Horizon 2020 funding programme, is a major contributor to the 35-year ITER project, which also involves the efforts of China, India, Japan, Korea, Russia and the United States.

7. Turning point: Reactor manager

Nature
531, 671 (2016) doi:10.1038/nj7596-671a
30 March 2016
This article was originally published in the journal *Nature*

Thomas Klinger describes how a once-troubled experimental fusion reactor got back on a solid footing.

http://www.nature.com/naturejobs/science/articles/10.1038/nj7596-671a

Last December, plasma physicist Thomas Klinger saw almost 15 years of work come to life when the Wendelstein 7-X 'stellarator' — an experimental nuclear-fusion reactor — was turned on in Greifswald, Germany. The initiative had to overcome numerous challenges, but Klinger now thinks that the once-troubled project is on a solid footing.

How is plasma physics contributing to the promise of nuclear fusion?

Fusion needs a hot ionized gas known as a plasma, so basic research on high-temperature plasmas is needed for their application in fusion-based power plants. The fusion process that happens in the Sun is very difficult to realize on Earth. We must rely on magnetic fields to keep smaller fusion reactions under control.

What challenges has the Wendelstein 7-X (W7-X) stellarator faced?

When I joined the Max Planck Institute for Plasma Physics in Greifswald in 2001, the plan was to produce the first plasmas around 2007. By 2003, everybody realized that the W7-X project was in deep trouble, suffering from serious technical and management issues. The institute started to introduce reforms but they were not sufficient. So in 2005, I was put in charge of the construction project.

How did you move the W7-X project forward?

We hired an outstanding technical director and engineer, Remmelt Haange. For the first two weeks, we sat together and scratched our heads. We identified three areas to address: the most pressing technical problems; a reorganization that would involve hiring 100 engineers; and a review of the assembly plan. I got a crash course in fusion engineering. In September 2007, a new plan was accepted and a decision was made to continue the project. It was pivotal because we were in danger of being stopped.

Did you require any further skills to bring the W7-X into operation?

Our team had to learn about industrial professionalism. There are certain well-established principles, requirements and documentation practices that were not part of our management system at the institute. We had to completely reinvent ourselves.

Compare the stellarator and tokamak nuclear-fusion technologies.

Both use a magnetic field to isolate the plasma and to control its temperature. The fundamental shape of this magnetic field must be a doughnut, or a ring. In a tokamak, such as the one being built for the ITER project near Cadarache, France, the magnetic field lines are twisted into shape by inducing a strong current in the plasma. But in a stellarator such as the W7-X, there is no current in the plasma. The twisting is done by the shape of the external coils of wire. Because it doesn't need a current, the stellarator is much more stable than the tokamak, and it can operate without interruptions — desirable for a power plant. The ITER and W7-X projects are very different. ITER is an international project with seven partners on a giant machine, so its management scheme is unusual and complex compared to that of the W7-X.

Will the W7-X be competitive with ITER?

The ITER tokamak is a fantastic machine, and it still delivers the best performance. The project is far ahead. But stellarators can catch up.

What are the next steps for the W7-X?

There will be two major shutdowns in which we will integrate large and complex components into the machine to enhance its performance. After 2020, we aim to produce high-performance plasmas. Our fundamental goal is to demonstrate that these plasmas can be created and kept stable for half an hour. That would be a breakthrough, and we hope to achieve this by 2025.

Why do humans need to harness fusion?

It's the only new primary source of energy that researchers are working on, and I'm convinced that it will be needed in the long run. The quest for energy will affect everything — from water to mobility. Sufficient energy means peace.

This interview has been edited for length and clarity

8. *NATURE CLIMATE CHANGE* | LETTER

Drivers of peak warming in a consumption-maximizing world

http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2977.html

Peak human-induced warming is primarily determined by cumulative CO_2 emissions up to the time they are reduced to zero[1, 2, 3]. In an idealized economically optimal scenario[4, 5], warming continues until the social cost of carbon, which increases with both temperature and consumption because of greater willingness to pay for climate change avoidance in a prosperous world, exceeds the marginal cost of abatement at zero emissions, which is the cost of preventing, or recapturing, the last net tonne of CO_2 emissions. Here I show that, under these conditions, peak warming is primarily determined by two quantities that are directly affected by near-term policy: the cost of 'backstop' mitigation measures available as temperatures approach their peak (those whose cost per tonne abated does not increase as emissions fall to zero); and the average carbon intensity of growth (the ratio between average emissions and the average rate of economic growth) between now and the time of peak warming. Backstop costs are particularly important at low peak warming levels. This highlights the importance of maintaining economic growth in a carbon-constrained world and reducing the cost of backstop measures, such as large-scale CO_2 removal, in any ambitious consumption-maximizing strategy to limit peak warming.

To view the complete article requires a subscription.

9. Climate science: Water's past revisited to predict its future

Matthew E. Kirby

Nature **532**, 44–45 (07 April 2016) doi:10.1038/532044a
Published online 06 April 2016
http://www.nature.com/nature/journal/v532/n7597/full/532044a.html

A reconstruction of 1,200 years of water's history in the Northern Hemisphere, based on proxy data, fuels the debate about whether anthropogenic climate change affected twentieth-century precipitation.

To read the whole article a subscription is required.

10. Northern Hemisphere hydroclimate variability over the past twelve centuries

Fredrik Charpentier Ljungqvist, Paul J. Krusic, Hanna S. Sundqvist, Eduardo Zorita, Gudrun Brattström & David Frank

http://www.nature.com/nature/journal/v532/n7597/full/nature17418.html

Accurate modelling and prediction of the local to continental-scale hydroclimate response to global warming is essential given the strong impact of hydroclimate on ecosystem functioning, crop yields, water resources, and economic security[1, 2, 3, 4]. However, uncertainty in hydroclimate projections remains large[5, 6, 7], in part due to the short length of instrumental measurements available with which to assess climate models. Here we present a spatial reconstruction of hydroclimate variability over the past twelve centuries across the Northern Hemisphere derived from a network of 196 at least millennium-long proxy records. We use this reconstruction to place recent hydrological changes[8, 9] and future precipitation scenarios[7, 10, 11] in a long-term context of spatially resolved and temporally persistent hydroclimate patterns. We find a larger percentage of land area with relatively wetter conditions in the ninth to eleventh and the twentieth centuries, whereas drier conditions are more widespread between the twelfth and nineteenth centuries. Our reconstruction reveals that prominent seesaw patterns of alternating moisture regimes observed in instrumental data[12, 13, 14] across the Mediterranean, western USA, and China have operated consistently over the past twelve centuries. Using an updated compilation of 128 temperature proxy records[15], we assess the relationship between the reconstructed centennial-scale Northern Hemisphere hydroclimate and temperature variability. Even though dry and wet conditions occurred over extensive areas under both warm and cold climate regimes, a statistically significant co-variability of hydroclimate and temperature is evident for particular regions. We compare the reconstructed hydroclimate anomalies with coupled atmosphere–ocean general circulation model simulations and find reasonable agreement during pre-industrial times. However, the intensification of the twentieth-century-mean hydroclimate anomalies in the simulations, as compared to previous centuries, is not supported by our new multi-proxy reconstruction. This finding suggests that much work remains before we can model hydroclimate variability accurately, and highlights the importance of using palaeoclimate data to place recent and predicted hydroclimate changes in a millennium-long context[16, 17].

To read the whole article a subscription is required.

11. ENERGY

Twisting design of fusion reactor is thanks to supercomputers

14 April 2016
http://horizon-magazine.eu/article/twisting-design-fusion-reactor-thanks-supercomputers_en.html

With hundreds of viewports of different lengths jutting from its outer wall, the Wendelstein 7-X looks otherworldly — more like science fiction than an experimental fusion reactor dreamt up by human beings. That's because the humans had help.

The breakthrough design of the fusion reactor, located in Greifswald, Germany, was only possible using extremely powerful computers known as supercomputers.

'It looks a little bit like an alien ship. But that's just the outcome of a very systemic physics and engineering process that is behind it,' explained project leader Professor Thomas Klinger of the Max-Planck-Institute for Plasma Physics in Germany.

The strange-looking layout of the Wendelstein 7-X, created with the help of EU research funds, is a result of the unique needs of its stellarator design, so-named because it mimics the conditions taking place inside stars, where huge amounts of energy are released by fusing hydrogen into helium.

Nuclear fusion could provide cheap, clean energy if attempts to build a fully operational reactor are successful. However, it is only possible at incredibly high temperatures, around 100 million degrees Celsius, where electrons are stripped from hydrogen atoms to create ionised plasma. Such plasma must be kept hot enough for fusion to occur and material walls would cool it down, which is why scientists must trap the plasma using powerful magnets.

'The magnetic field coils have to have just the shape to create the right magnetic field,' Prof. Klinger said. 'We have been doing a long research phase of 20 years in which it was found out what the actual field is we need, or the plasma needs, for being well-confined.'

Those requirements led to the Wendelstein device, where scientists, with the help of the supercomputers, created a uniquely shaped superconducting magnet system to hold the plasma. That is then surrounded by an outer vessel to keep the coils cool in a vacuum at -270 degrees Celsius with liquid helium.

Keeping the plasma confined is the number one challenge faced by scientists. In February, the project began testing the system with hydrogen plasma for the first time.

'The first hydrogen plasma had a duration of 40 milliseconds, so pretty short. Since then, we have made a lot of progress, and we were able to create hydrogen plasma more recently for 8 seconds. So that's an increase by a factor of 200,' Prof. Klinger said.

By the summer of next year, the team hopes to be running the stellarator at full power for ten seconds, after installing more graphite elements for the wall. After that, they plan to introduce active water cooling, which they hope will enable them to run the device for 30 minutes.

Wild design

The wild design of the stellarator is crucial to giving scientists the greatest flexibility to try out different magnetic fields to see how the plasma behaves and if the confinement is getting better.

'We have seven different current circuits, and we can control each current circuit to run the coil separately. That gives us, literally speaking, seven knobs to turn … with which we create different magnetic field configurations,' Prof. Klinger said.

Trying to find the best confining and heat insulating field is one of the main scientific tasks of the experimental device, but the complex behaviour of the trapped plasma makes that difficult.

The trick of the Wendelstein's stellarator design is that the external magnetic coils twist the entire magnetic field itself, like a corkscrew, to counteract against unwanted drift motions.

In the south of France, researchers at the ITER project are testing an alternative, doughnut-shaped fusion reactor design, known as a tokamak.

While tokamaks operate in pulses, where a strong electric current in the plasma is ramped up and down, the idea behind the stellarator is that the magnetic field is twisted by the external magnetic field coils which means the plasma can be held in a steady state.

‘What we are aiming for is to maintain the plasma for 30 minutes, so 1 800 seconds,’ Prof. Klinger said. ‘In a stellarator, you can create the plasma and basically it stands there without interruption for hours, days, months ... or years.’

Turbulence

What has held stellarators back until recently is getting the plasma right.

Much like the violent surface of the sun, waves in the plasma create a constant mixture of uneven forces. The plasma, sitting in the magnetic field, is not flowing calmly, but rather sloshing about, reacting to magnetic fields but also generating its own.

‘We call that the “fluid picture” of a plasma,’ Prof. Klinger said. ‘It's always just a picture. We scientists only make a picture of reality, and that is a useful picture how to describe what is happening.’

Seen from another perspective, plasma behaves more like a gas, trying to expand and escape from its container. And turbulence has caused a number of headaches.

‘Without turbulence, fusion devices would be much smaller than what we have now, because in order to counteract the heat loss, you have to make the machine big,’ Prof. Klinger explained.

The larger the volume of the reactor, the more energy which can be created. That bigger amount offsets energy that escapes confinement through the surface.

‘If you can find ways to reduce the turbulence … you make the heat insulation properties of the plasma better, and you can basically build smaller machines,’ Prof. Klinger said.

While large 1 gigawatt fusion plants could be the backbone of an electrical network, smaller machines could make easier-to-build power stations for industrial plants situated right inside cities.

That’s because unlike nuclear fission plants, there is no chain reaction that needs to be carefully controlled.

‘If anything goes wrong, if somebody pushes the wrong button or an aeroplane flies into the power station, then the plasma just stops existing. Very quickly, within a tenth of a second, it recombines at the wall,’ Prof. Klinger said.

‘The plasma is so thin, there's so little mass, at a power station we are talking a maximum of 1 gram of plasma.

Compare that to the 30 000 ton weight of the machine, and then guess who wins.’

12. M2 Communications 04/14/2016 6:21 AM ET

Independent review backs 'world class' UK fusion programme

http://www.bloomberg.com/research/markets/news/article.asp?docKey=600-201604140621M2______EUPR_____b60c0000018e338d_3600-1

https://www.gov.uk
The Engineering & Physical Sciences Research Council (EPSRC), commissioned an independent review of nuclear fission and fusion research in the8 UK, to guide its future strategy.
The review panel consisted of nine UK and international nuclear experts and interviewed a range of representatives from the research community, industry and Government in the course of its assessment.
The review findings were taken at the EPSRC Council meeting in March 2016 and the report has recently been published. The review found the magnetic confinement fusion programme in the UK, based at Culham, to be of "world-class quality, in facilities, people and impact." The JET facility, which UKAEA hosts on behalf of the European Commission was found to be "of the highest level of international importance". UKAEA is current undertaking a major upgrade to its MAST fusion experimental reactor, which includes a new cutting-edge fusion exhaust system. The panel said that the upgrade "will result in a facility that is world-leading in its particular design space." And it praised the well integrated links with fusion research at British universities.

New activities in materials research, remote handling and fusion system design are described as "wisely chosen with a view to the long term leadership of the UK fusion programme." The key role that the new Materials Research Facility and Remote Applications in Challenging Environments centre will play in fusion and wider areas - including fission - is also strongly supported.
EPSRC Independent Review of Fission and Fusion
https://www.epsrc.ac.uk/newsevents/pubs/indrevfissionfusion/

13. Court dismisses appeal against Darlington refurbishment

15 April 2016

http://www.world-nuclear-news.org/C-Court-dismisses-appeal-against-Darlington-refurbishment-1504168.html

Canada's Federal Court of Appeal has unanimously dismissed a judicial review of the environmental assessment (EA) for Ontario Power Generation's (OPG) planned refurbishment of the Darlington nuclear power plant. The lawsuit was brought by groups led by Greenpeace Canada.

The court found that there were no gaps or errors in the 2013 EA, which determined the project would have no significant adverse effects on the public or the environment. It also found that there was "nothing unreasonable" about determinations made by the responsible authorities that reviewed the EA, and found that arguments brought by the intervenors were not borne out by evidence.

Greenpeace Canada, the Canadian Environmental Law Association, Lake Ontario Waterkeeper and Northwatch had brought the appeal against a November 2014 federal court decision to dismiss their application for judicial review.

OPG president and chief nuclear officer Glenn Jager said that the court decision was a "vote of confidence" in the quality of work that went into the EA application and in the licensing process. "We have been preparing for this project since 2009, and we're ready to deliver the job safely, on time and on budget", he said.

OPG announced the CAD 12.8 billion ($9 billion) project to refurbish the four Darlington Candu units in January, after nine years of scoping work and detailed planning. The refurbishment of the first unit will begin in October, and the project will take ten years to complete for all the units. Refurbishment will enable the units, which supply about 20% of Ontario's electricity, to continue to operate for a further 30 years.

Researched and written
by World Nuclear News

14. Three more years for USA's Pilgrim plant

15 April 2016

http://www.world-nuclear-news.org/C-Three-more-years-for-USAs-Pilgrim-plant-1504167.html

The Pilgrim nuclear power plant will be refuelled for the final time in 2017 and will cease operations on 31 May 2019, Entergy announced yesterday.

Entergy notified grid operator ISO New England Inc in October 2015 that Pilgrim would not participate in the capacity market after 31 May 2019, meaning that the plant would have to shut by 1 June 2019 at the latest. At that time, the company did not rule out the possibility of shutting the plant at the end of its current operating

cycle in 2017. Entergy cited poor market conditions, reduced revenues and increased operational costs behind its decision to close the only nuclear power station in the state of Massachusetts.
Entergy will prepare a Post-Shutdown Decommissioning Activities report, which must be submitted to the US Nuclear Regulatory Commission no later than two years after the plant is shut down. The plan will describe planned decommissioning activities, a schedule, cost estimate and environmental impacts and will be a public document. Entergy has also said it will create a Nuclear Decommissioning Citizen's Advisory/Engagement Panel "to share information and educate the public".
The decision to operate Pilgrim's single 680 MWe boiling water reactor for a further three years means that the unit will enter its final refuelling outage in the spring of 2017. The plant is currently operating under increased regulatory oversight following on from a low-to-moderate safety finding in relation to issues involving safety relief valves.
The unit entered service in 1972 and is currently licensed to operate until 2032.

Researched and written
by World Nuclear News

15. Operating licence application submitted for Finnish EPR

14 April 2016

http://www.world-nuclear-news.org/NN-Operating-licence-application-submitted-for-Finnish-EPR-1404164.html

Finnish utility Teollisuuden Voima Oyj (TVO) has today submitted its operating licence application for unit 3 of the Olkiluoto nuclear power plant. The first-of-a-kind EPR plant is scheduled to start up in late 2018.

TVO announced today that it has submitted its 130,000-page application to the Finnish Ministry of Employment and the Economy. The application contains information on, among other things, the technical and operational safety principles, arrangement for nuclear waste management, and details of TVO's expertise and financial position.
In addition to seeking approval to operate Olkiluoto 3 for an initial 20-year period (from the beginning of 2018 to the end of 2038), TVO's application also seeks permission to use the existing on-site interim storage facilities for the used fuel and other radioactive wastes that will be generated by the unit over this period. The application does not concern the use of final disposal facilities for nuclear wastes.
The application will now be reviewed by the Finnish nuclear regulator STUK, as well as several ministries and certain other authorities and communities. STUK will give its safety assessment for the application, while the others will submit statements to the Ministry of Employment and the Economy. The Finnish government will make a decision on TVO's application based on the ministry's recommendations.
STUK said that as it has already inspected and approved the design of the plant during the construction phase, the focus of its assessment for the operating licence will be verifying updated safety analyses and TVO's preparation for operation. It said this assessment will take about 18 months to complete and that STUK will deliver its statement to the ministry at the end of 2017.
"TVO has already submitted most of the operating licence materials to STUK", said Tapani Virolainen, deputy director of STUK's nuclear reactor regulation department. "STUK has granted a six-month extension only for the provision of certain analysis results."
TVO senior vice president for the Olkiluoto 3 project Jouni Silvennoinen said the submission of the operating licence application is "an important milestone" towards commissioning of unit. "Now the project is moving from installations to testing. The operating licence application process is the most important phase of the final acceptance of a nuclear power plant project before start up of the new power plant unit," Silvennoinen said.
TVO said it anticipates obtaining the operating licence for Olkiluoto 3 towards the end of 2017, after which nuclear commissioning will start at the unit. Commercial operation of the reactor is expected to begin by the end of 2018.
Instrumentation and control system testing at Olkiluoto 3 started in January and last week testing began of the first process system - the seawater system. The company said the main electromechanical installations, including piping works, will be completed by mid-2016. The first-of-a-kind EPR at Finland's Olkiluoto plant has been under construction since 2005 and has seen several revisions to its start-

up date, which is now expected by 2018. The Flamanville EPR in France, construction of which began in 2007, is now expected to start up in late 2018.
Taishan 1 in China, which has been under construction since 2009, is expected to start up in early 2017, while Taishan 2 is scheduled to begin operating later that year.
Researched and written
by World Nuclear News

16. Nuclear industry needs to improve communication

14 April 2016

http://www.world-nuclear-news.org/RS-Nuclear-industry-needs-to-improve-communication-14041601.html

Safety and security are the "overriding and enduring priorities" of the nuclear power industry and plant operators "need to anticipate new safety concerns", such as terrorism and cyber security, EDF Energy CEO Vincent de Rivaz said at a conference in London today.
In his opening address to the Nuclear Safety Symposium, which the utility hosted together with the World Association of Nuclear Operators (WANO), de Rivaz said the "digital revolution has changed the way that people talk to each other, which impacts openness and transparency".
"Cooperation across our industry, companies and borders continues to be paramount in addressing and anticipating risks and opportunities," he said.
"Social media channels, like Facebook and Twitter, can be an opportunity for us to listen and engage on energy issues and EDF Energy has created digital tools based on the same principle as its physical visitor centres. These tools have been viewed over 1.3 million times," he said. "As an industry we must harness the power of social media to broaden

understanding of what we do, but we must also pay attention to the risks and we must be equipped to respond to unfounded [statements] on social media. We must be equipped to address the challenge of inaccurate information that can go viral in a matter of minutes if not seconds. This is a vital part of gaining and maintaining public trust."

Communication is key

Agneta Rising, director general of the World Nuclear Association, told the more than 300 delegates at the conference that the industry has failed to talk enough about one of the key lessons to be drawn from the Fukushima Daiichi nuclear power plant accident in Japan, in March 2011. That lesson is communication, she said.
"If an accident occurs, there will be many voices seeking to be heard and media channels will want to use the information sources they know and trust. And trust has to be gained before an event," Rising said.
The World Nuclear Association supports the viability of nuclear energy, gaining trust in nuclear technology, its management and oversight, she said, and the organisation does this through the provision of "constantly high-level information as well as media outreach".
"We do this for the day-to-day operations of nuclear facilities as well as for nuclear events or accidents with informed commentary on the implications for public safety and the future of the industry."
The Association has the world's most read website on nuclear energy, with 11 million page views per year, she noted. It has 182 reference papers "covering every aspect of nuclear energy that are used around the world". In addition, *World Nuclear News* has "up-to-the-minute expert reporting" that is published on the internet and sent to subscribers by email and also through social media.
During an accident, such as at Fukushima, the affected operator will be faced with the "double burden", she said, of dealing with the safety issue at hand and communicating with the regulator, with the national bodies, with the local and national media and with the stakeholders. And if the accident is serious, the operator will face an "international media onslaught".
"Our role is to support and to amplify the communications of an effective nuclear operator, of national and international nuclear bodies, as well as of governmental and intergovernmental bodies. We have taken on this role because we see that WANO and the IAEA are restricted in their communication," Rising said.
"Of course, the World Nuclear Association has to have factual information and this has to be checked with the source, but we

don't need governmental approval, so we can act faster." WANO has "little or no remit" to communicate with the public directly and the IAEA can "do little more than wait and do what the governments are saying". A lack of communication "risks a vacuum that will quickly be filled by rumours".

Fukushima was the first nuclear accident to occur in the world with 24/7 news channels, widespread access to the internet and social media, she said.

"There were many lessons to be learned after Fukushima – technical, institutional, organisational, human, and communication. And in the past five years I have heard people talking a lot about these lessons, except communication. This has been much less discussed and no one has said, 'We have to step up and have more resources in this area'.

"But the World Nuclear Association decided last year that its Secretariat would implement a crisis communication function and we have made a plan for this, it will be done during this year, and we have shared this plan with WANO as well."

Following the Fukushima accident, there were "pages and pages of numbers coming out with no interpretation of their relevance", she said. "There is a tendency to think that publishing more and more data demonstrates transparency, but it doesn't."

The World Nuclear Association has 178 member organisations from 37 countries.

Researched and written
by World Nuclear News