ITER Forum website Update 8/15

B.J.Green (25/8/15)

1. Journalists link solar science news to climate—and to the climate controversy

The coverage includes outright confusion, not to mention politicization, about the newly predicted "mini ice age."

Steven T. Corneliussen

15 July 2015

http://scitation.aip.org/content/aip/magazine/physicstoday/news/10.1063/PT.5.8127;jsessionid=cuixkj5kegqg.x-aip-live-02

The Royal Astronomical Society press release "Irregular heartbeat of the Sun driven by double dynamo" explains that at the recent National Astronomy Meeting in Wales, Northumbria University astrophysicist and mathematics professor Valentina Zharkova reported on a new model of the Sun's solar cycle. The model suggests that "solar activity will fall by 60 per cent during the 2030s to conditions last seen during the 'mini ice age' that began in 1645." The resulting media stir merits notice.

No doubt this solar science news, bearing as it does on a topic important to everyone—weather—would have inspired international press attention even in the absence of a flourishing controversy over something else related to weather, human-caused climate disruption. In any case, the press attention includes plenty of what's predictable: not just linkage of the solar-causation and human-causation realms, but outright confusion of the two as well.

An unconfused *Daily Mail* summarized the solar news and the weather implications with one of its multiple-subhead headlines:

Is a mini ICE AGE on the way? Scientists warn the sun will 'go to sleep' in 2030 and could cause temperatures to plummet

- New study claims to have cracked predicting solar cycles
- Says that between 2030 and 2040 solar cycles will cancel each other out
- Could lead to 'Maunder minimum' effect that saw River Thames freeze over

The Royal Astronomical Society release links to a Wikipedia entry defining the Maunder minimum as the "prolonged sunspot minimum" period from about 1645 to about 1715 "when sunspots became exceedingly rare." Wikipedia notes that it "coincided with a period of lower-than-average European temperatures."

The solar news article at the UK's *Mirror*—headlined "Planet Earth set to shiver through 'mini ice age': Will it save humanity from global warming?"—eventually gives an answer to its headlined question: No. The article reports on the abstract from the 2010 *Geophysical Research Letters* paper "On the effect of a new grand minimum of solar activity on the future climate on Earth," by Georg Feulner and Stefan Rahmstorf. That paper ends by declaring that "a new Maunder-type solar activity minimum cannot offset the global warming caused by human greenhouse gas emissions" and by adding that moreover, "any offset of global warming due to a grand minimum of solar activity would be merely a temporary effect, since the distinct solar minima during the last millennium typically lasted for only several decades or a century at most."

Haaretz in Israel, also anticipating the inevitable public linkage and confusion, noted that Zharkova's "prediction has nothing whatsoever to do with the phenomenon of human-driven climate change." An anecdotal sampling of the coverage shows that many journalists played the story straight, just as the *Daily Mail* did.

But the subhead on the *Register*'s article classifies the solar-science news as fitting into the "climate/solar debate." And indeed that's where many journalists have placed it. First on the "Read More" list following *Huffington Post UK*'s article is a link to a piece headlined "Global warming 'is delaying the next ice age.'" The *Telegraph* interrupts its online report after five sentences with this note irrelevantly directing readers to a diatribe alleging politically motivated scientific malfeasance: "Fiddling with temperature data is biggest science scandal ever (31,000 comments)." The *Examiner* ends a solar news report with this:

What does this mean for global warming activists? It is too soon to tell, but the "Little Ice Age," which occurred between 1300 and 1850 (per Britannica.com), was a period of mostly decreased solar activity divided by intervals of increased solar activity. It is as yet unknown whether the overall increase of temperatures on Earth in the past century will in some way offset a prolonged sunspot minimum, if and when the next one occurs.

An *Examiner* commentary on the solar news begins by reporting, "Some climate scientists are so worried sick about global warming that they are showing signs of psychological stress, Esquire informs us. UPI has some good news and some bad news concerning climate change on Saturday." In fact the cited brief UPI article never mentions climate or climate change, though maybe it's technically truthful to use that language about a decade- or decades-long cold period. The opening paragraph continues:

The good news is that global warming is not going to happen after all, at least for a long while. The bad news is that we're in for a mini-ice age starting about 2030. The culprit is an engine that affects climate far more powerful than anything humanity can devise. That engine is the sun.

The commentary ends with this:

The prediction suggests that far from wanting to cut back on carbon dioxide emissions, the world community might want to consider increasing them instead. A little greenhouse effect might go a long way toward mitigating the frigid future that yet another group of scientists say is in store for us. On the other hand, the dueling predictions suggests [*sic*] that some caution and no little flexibility might be in order where policies related to global warming or global cooling or whatever constitutes climate change is this week.

The *American Thinker* commentary "Scientists warning of global cooling once again!" confuses the predicted brief period with global cooling, recycles the 1970s "global cooling" argument that Inside Science News Service has debunked, confuses climatology with weather prediction ("climatologists can't predict the weather a week ahead," it sneers), calls the solar prediction the "new political viewpoint of the environmental commissars," and proposes that the finding "raises a big question about global warming. Will the two cancel each other out?"

In one of the online discussions, a reader cited a *Skeptical Science* write-up concluding that "science is quite clear that the human influence on climate change has become bigger than the sun's."

Steven T. Corneliussen, a media analyst for the American Institute of Physics, monitors three national newspapers, the weeklies Nature *and* Science, *and occasionally other publications. He has published op-eds in the* Washington Post *and other newspapers, has written for NASA's history program, and is a science writer at a particle-accelerator laboratory.*

2. *Wall Street Journal*: "A nuclear renaissance hasn't materialized"

The *Bulletin of the Atomic Scientists* sees renewables "surging" past nuclear in many countries.
Steven T. Corneliussen

03 August 2015
http://scitation.aip.org/content/aip/magazine/physicstoday/news/10.1063/PT.5.8130;jsessionid=7e0gtqg0zx0f.x-aip-live-03

A November 2014 *Wall Street Journal* news article asked whether the US government can "revive nuclear power." Now the 28 July *WSJ* Business and Tech section front page, observing languishing nuclear construction, has offered an answer: probably not. The *Bulletin of the Atomic Scientists* agrees.
In November, the *WSJ* consulted industry experts about nuclear power's future amid problems and disadvantages: newly abundant cheap natural gas, public perceptions since the tsunami-induced Fukushima nuclear disaster, the costs of new construction, the vexing problem of nuclear waste, and what one of the experts lamented as the absence of a "reasonable carbon policy [that] would positively influence the economics" of nuclear power.
The July piece began,
Building nuclear reactors out of factory-produced modules was supposed to make their construction swifter and cheaper, leading to a new boom in nuclear energy.
But two US sites where nuclear reactors are under construction have been hit with costly delays that have shaken faith in the new construction method and created problems concerning who will bear the added expense.
The article quoted Joseph "Buzz" Miller, executive vice president of nuclear development for Georgia Power, which is responsible for one of the two sites: "The promise of modular construction has yet to be seen." It mentioned the problem of decay of industrial capabilities and skills for building nuclear plants. The final paragraph sums up the situation:
US utilities proposed building more than two dozen reactors five years ago before the shale-gas revolution drove down the price of natural gas and made plants that burn gas a more attractive option for the power industry. Last month, the Nuclear Regulatory Commission said it was folding a division to manage construction of new reactors back into the division from which it was pulled a few years ago.

To make what's implied explicit, the online version adds, "acknowledging a nuclear renaissance hasn't materialized."
The *Bulletin of the Atomic Scientists* sees it the same way. Concerning the *World Nuclear Industry Status Report 2015*, it says:
This year's report comes at a time when most energy and environmental experts shy away from the words "nuclear renaissance" but some view nuclear power as an indispensable substitute for fossil fuels in global efforts to combat climate change. Current trends, however, suggest that a rapid ramp-up of nuclear power is unlikely, and that renewable energy is surging past nuclear power in many countries.

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3. Why did the US abandon a lead in reactor design?

A questionable reshaping of reactor research 45 years ago has had long-term consequences.
Cheryl Rofer

07 August 2015
http://scitation.aip.org/content/aip/magazine/physicstoday/news/10.1063/PT.5.2029?utm_source=Physics+Today&utm_medium=email&utm_campaign=6021642_Physics+Today%3a+The+week+in+Physics+3-7+August&dm_i=1Y69,3L2BU,E1OV2B,CVCOS,1

Sometime in the late 1960s, a great shakeup occurred in nuclear reactor research. As a young employee of the reactor division at the Los Alamos Scientific Laboratory at that time, I was shocked and confused when the division was suddenly dissolved. Now that we are again considering alternatives to light-water reactors, several narratives have sprung up to explain why these alternatives were abandoned.
Recently, I decided to research that decision using publicly available sources. What I found was remarkable. The key player was Milton Shaw, who directed the Atomic Energy Commission’s (AEC) Reactor Development and Testing Division (RDTD) at that time. Shaw refocused the US civil nuclear program toward a single goal of the liquid-metal fast breeder reactor, making a number of strategic mistakes that have had long-term safety consequences for the industry.
Shaw was a protégé of Admiral Hyman Rickover, known as the father of the US nuclear navy. Rickover and his team successfully developed nuclear reactors for submarines and then aircraft carriers, releasing them from the need for fossil fuels as the main source of propulsion. The first nuclear submarine, USS *Nautilus*, was authorized by Congress in July 1951 and was launched January 1954, two and a half years later. The aircraft carrier USS

Enterprise was authorized in 1954 and commissioned in 1958, less than four years later.

In December 1953 US President Dwight D. Eisenhower focused on peaceful uses of nuclear power in his “Atoms for Peace” speech at the United Nations in New York City. The fastest way to implement his vision was for Rickover’s team to adapt the navy’s USS *Enterprise* reactor design for civilian use. Within months, ground was broken for the first nuclear electrical generating plant at Shippingport, Pennsylvania. Less than four years later, the plant was operational. Shaw led the team.

These were impressive engineering and patriotic successes at a time when the US felt the Cold War pressure of competing with the Soviet Union. Rickover and his team were considered effective, although there were stories about bullying and dictatorial management practices.

Extending civilian nuclear power

The success at Shippingport, and other civilian reactors, raised Shaw’s visibility. In 1964 he was made director of the RDTD. Commercial firms were getting into the reactor business, extending the navy’s pressurized light-water reactor (PWR) design to larger sizes. However, nearly all the main reactor research was being conducted at the US national laboratories.

Argonne and Oak Ridge national labs were involved with the design of the first submarine reactor, which was built by Westinghouse Bettis Laboratory (now owned by Bechtel) and tested at the Idaho National Reactor Testing Station (now Idaho National Laboratory). Although the first reactors had been carbon-moderated and gas-cooled, water served both purposes in the naval reactors. The water also shielded the crew from radiation.

As more commercial reactors were built for power plants, their size and operating temperatures were increased. To serve their purpose, they would need to be sited close to populated areas. Though an earlier safety standard required that reactors be kept in desolate areas away from large population centers in case of an accident, reactors would be uncompetitive with other forms of power production if they were sited too far from their energy market. Safety studies were duly carried out at the national labs on containment vessels as an alternative safety mechanism. The most damaging accident thought to be possible (“maximum credible accident”) was losing reactor water coolant when a pipe broke. Although losing the moderator would end the fission reactions, the heat generated by fission products might melt the core. A facility was planned at Idaho to test such an accident.

It was not uncommon at that time for engineers to test equipment to failure. For example, nuclear-powered rocket engines, which also being developed at the time, were tested at the Nevada Test Site. In 1965, as part of this program, the Kiwi-TNT test simulated the maximum credible accident for that reactor: a rapid nuclear excursion, such as might happen if the reactor powering a rocket fell into the ocean.

The national laboratories were also investigating a wide variety of reactor designs, from liquid-metal-cooled reactors through high-temperature gas-cooled reactors to molten salt reactors. The reactors might be fueled by uranium, plutonium, or thorium. Some of them, called breeders, made more fuel than they used. Breeders would make the most of what were then believed to be very limited uranium reserves by creating plutonium as the uranium was burned. Shaw’s Reactor Development and Testing Division funded both safety studies and exploratory reactor designs.

The pivot point

By the late 1960s, two breeder reactors had been operating in the US: An experimental breeder reactor (EBR-I) built in Idaho in 1949 to prove the principle of breeding and the Enrico Fermi breeder reactor near Detroit, Michigan, for which construction started in 1963. Both used liquid sodium as coolant, which has ideal nuclear properties for working with fast neutrons—useful for efficient breeding of plutonium. Sodium is a solid but soft metal at room temperature and reacts strongly with water. This, as researchers discovered, makes it difficult to work with: EBR-1 suffered a partial meltdown in 1955, as did Fermi in 1966, both from blocked coolant channels.

Starting in about 1968, the resources of Shaw's Reactor Development and Testing Division were turned solely towards the development of a liquid metal fast breeder reactor (LMFBR), and all other projects were abandoned. Why? The answer to that question would require more detailed research in the AEC archives. Open internet sources indicate that Shaw probably had the approval of AEC Chairman Glenn Seaborg and most of the other commissioners. The AEC, born out of the wartime Manhattan Project as the civilian agency overseeing all uses of nuclear power, was accustomed to acting in secrecy. There is some indication that the deliberations surrounding this decision were more secretive than others.

If RDTD focused narrowly on a single objective, this practice was consistent with prior naval reactor development. For one example, the second nuclear submarine, USS *Seawolf*, was originally fitted with a liquid-sodium reactor, which was replaced after a few years with the standard PWR used for nuclear submarines.

At the time, with rising energy demands and predictions of uranium deposits running out, a breeder reactor program seemed the only logical choice if nuclear energy was to contribute significantly to US energy needs. Shippingport and the naval reactors had operated without any serious problems for a decade, which could be taken as evidence that safety issues had been mastered. Rickover was proud of his safety program, as indicated in his testimony to Congress in 1979. The result was that the national laboratories' safety research was suddenly cut back and later ended, because it was believed unnecessary, or acceptable to delegate to industry. Research into alternative reactor designs at the labs also ended.

Shaw seems not to have consulted the senior staff of the national laboratories on the decision in any significant way. Alvin Weinberg, director of Oak Ridge, was reported to have been livid. The reactor division at Los Alamos was shut down. Work at Idaho was redirected multiple times. A program manager for the LMFBR was installed at Argonne who reported directly to Shaw.

In response to Shaw's initiatives in 1967, Albert V. Crewe, then director of Argonne National Laboratory, noted that Argonne's purpose was "not to build submarines but to produce knowledge."

Shaw's application of Rickover's narrow focus and command-hierarchal structure marked a break with past management practices of the national laboratories. Until then, reactor programs at the national laboratories had been developed through consultation between the AEC and the laboratories, and allowed for exploratory projects. This broad view came from the Manhattan Project, in which multiple pathways toward the goal of an atomic weapon were investigated.

Outcomes

Narrowing the government's reactor program to sole emphasis on the LMFBR probably had more influence on the shape of today's nuclear industry in the US—and to its opposition—than any other single decision after the Manhattan Project. Shaw's program failed in its primary objective, to build a prototype LMFBR at Clinch River, Tennessee. It also left vulnerabilities in the light-water reactor designs that would be used in power plants around the world. Few alternative reactor designs, such as gas-cooled reactors, were built into US power plants, and those few were commercially unsuccessful.

The LMFBR program failed for many reasons. It moved more slowly and cost more than was expected. Concerns about proliferation rose during the 1970s. Additional reserves of uranium were found, making breeders less attractive. Congress's Joint Committee on Atomic Energy—dissolved when AEC was split into the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC)—was no longer available to provide single-minded financial support. In contrast, France, Russia, China, and Japan all operated commercial-scale liquid-metal-cooled fast reactors. The AEC's dual role as both regulator and developer of nuclear energy was often questioned and criticized. The cut in safety research was the final straw that led to the 1975 splitting of the AEC into ERDA and NRC. Two years later, ERDA was combined with the Federal Energy Administration to form the DOE. Like the regulatory arm of the AEC, the NRC has no funding for safety research but over the years DOE has sporadically addressed some reactor safety concerns, as do the reactor manufacturers.

The narrowed focus of the US reactor program left dangerous gaps. Both the Three-Mile Island (1979) and Fukushima (2011) reactor meltdowns were due to loss of coolant, the type of accident on which Shaw shut down research. Modifications now being proposed might have been introduced years ago, in time to prevent those accidents, if that research had continued.

In fact, because that research was curtailed, some of the scientists in these divisions took their safety concerns and expertise to people and organizations that would listen to them. The Union of Concerned Scientists, formed in 1969, and other groups benefitted from their knowledge transfer. Such groups would have emerged in any case, but the alienation of scientists working on reactor safety and the real problems they addressed strengthened their resolve and mobilization.

Development is restarting on reactor designs that were mothballed by Shaw's decision nearly 50 years ago. Thorium, liquid-salt-fueled, and liquid-metal-cooled reactors are being considered by the national labs, some universities, and startup firms. So too are more innovative, safer versions of light water reactors. None of those designs can be expected to come into use for a decade or more. Corporate research will be very focused, and we cannot expect that safety issues will be a primary consideration. Contrary to claims by some promoters of the new designs, experiments conducted through the 1960s are barely proof of concept. Regulations and available technology have changed too much for the earlier data to be reliable.

Not a positive story

Shaw's redirection of the American nuclear program is little mentioned in official histories on the web. Its effect on the breakup of the AEC is partially recognized on the NRC's history page, and not at all in a DOE history of ERDA. Undoubtedly relevant documents exist in AEC and national laboratory archives.

The story is not a positive one for the AEC. Although most biographies recognize that Admiral Rickover's management of his programs was controversial, he is still revered in the US nuclear navy and beyond. In the civilian industry, a standard term for nuclear power reactors collectively is "nuclear fleet," recalling their naval origins. There is little motivation to revisit that history, but understanding the strategic mistakes can help us chart a more productive way forward.

Shaw and the AEC failed to recognize the differences between developing naval reactors and developing the LMFBR: the comparatively more technical unknowns requiring investigation, the culture and history of the national laboratories in contrast to the captive naval reactor labs, and the need to avoid perceptions or realities of conflicts of interest. They eliminated alternative paths that might have provided better commercial reactors or developed safety fixes. Many of the negative consequences have endured for forty years and more. Perhaps looking back at what went wrong can help to repair the damage.

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4. Japan restarts first nuclear reactor since Fukushima disaster

Justin McCurry in Tokyo

Tuesday 11 August 2015 18.40 AEST

Sendai nuclear plant in southern Japan is first to begin operation since 2011 Fukushima meltdowns, despite anti-nuclear protests

http://www.theguardian.com/environment/2015/aug/11/japan-restarts-first-nuclear-reactor-fukushima-disaster

Japan has begun a controversial return to nuclear power generation with the restart of a reactor in the country's south-west, four and a half years after its faith in atomic energy was shattered by the triple meltdown at Fukushima Daiichi.

Kyushu Electric Power, the operator of the Sendai plant, said it had restarted one of the facility's two reactors on Tuesday morning, in defiance of strong local opposition.

The move marks the first time Japan has generated nuclear power since a post-Fukushima shutdown of all its 44 operable reactors two years ago.

While police scuffled with demonstrators outside the plant, public broadcaster NHK showed workers in the control room as the reactor whirred into action for the first time since it was mothballed in May 2011.

Kyushu Electric said the restart had gone without a hitch. The 30-year-old Sendai No 1 reactor is expected to reach full capacity next month. The second Sendai reactor is due to restart in October.

In an attempt to keep Japan's fledgling economic recovery on track, the prime minister, Shinzo Abe, has pushed for a return to nuclear power generation in spite of opinion polls showing that most voters oppose restarts.

Backed by business and industry lobby groups, Abe has warned that Japan cannot afford to continue importing huge quantities of oil and natural gas, while the growing reliance on thermal power generation has stalled Japan's efforts to reduce greenhouse gas emissions.

"There are very strong vested interests to reopen nuclear reactors. Accepting them as permanently closed would have financial implications that would be hard to manage," Tomas Kaberger, chairman of the Japan Renewable Energy Foundation, told Associated Press.

Japan's powerful pro-nuclear lobby is hoping a safe restart at Sendai, about 1,000km south of Tokyo, will help the public overcome the trauma caused by the Fukushima meltdown.

The March 2011 disaster, triggered by a powerful earthquake and tsunami, forced the evacuation of 160,000 people, many of whom might never return home.

"It is important to restart reactors one by one from the perspective of energy security, the economy and measures against global warming, but safety always comes first," the industry minister, Yoichi Miyazawa, told reporters, adding that the government would "deal responsibly" should another accident occur.

Just ahead of the restart, Abe said Sendai's reactors had passed "the world's toughest safety screening". He added: "I would like Kyushu Electric to put safety first and take utmost precautions for the restart."

The Sendai plant, where more than £64m has been spent on new safety systems, was the first to meet strict new standards introduced after the Fukushima disaster.

Japan's revamped Nuclear Regulation Authority (NRA) said the new safety checks meant there would be no repeat of the Fukushima catastrophe. "A disaster like that at … Fukushima Daiichi nuclear plant will not occur," NRA chairman Shunichi Tanaka said in a recent interview with the Nikkei business paper. He conceded, though, that there was "no such thing as absolute safety".

The government wants nuclear power to account for as much as 22% of Japan's energy needs by 2030, despite continuing troubles at Fukushima Daiichi, where the removal of melted fuel from damaged reactors is not due to begin until 2022. Decommissioning the wrecked plant is expected to take 40 years.

Greenpeace said the restart "will not reverse the terminal decline" of Japan's nuclear industry. "Even though one nuclear reactor has restarted, the nuclear industry is still fighting for its very survival in Japan," said Mamoru Sekiguchi, energy campaigner at Greenpeace Japan.

Sekiguchi echoed local concerns that authorities in Sendai had not devised a comprehensive evacuation plan for more than 200,000 people living within a 30km radius.

Aside from the risk from earthquakes and tsunami, the Sendai plant is located in a volcanically vulnerable region, with Sakurajima, one of Japan's most active volcanoes, just 50km away.

“The lengths to which safety issues have been ignored in the Nuclear Regulation Authority’s review process for the Sendai plant restart shows just how desperate the nuclear industry and their government allies are,” Sekiguchi said. “Rather than a nuclear renaissance, much of Japan’s ageing nuclear reactor fleet will never restart. Prime minister Abe and the nuclear regulator are risking Japan’s safety for an energy source that will likely fail to provide the electricity the nation will need in the years ahead.”

Greenpeace predicts nuclear will provide 2%-8% of Japan’s electricity generation by 2030, far lower than the government’s target.

Tobias Harris, a Japan analyst at Teneo Intelligence in Washington, said it was unlikely that Tuesday’s restart would herald a quick return to nuclear as a major source of energy.

“The Sendai restart is unlikely to trigger a cascade of restarts that significantly reduces Japan’s post-2011 dependence on imported fossil fuels,” he said. “Each nuclear power plant faces a unique set of technical, operational, legal, and political challenges, suggesting that the delays that have dogged the first restart will be seen at other locations.”

Japan’s nuclear operators have applied for approval to restart 25 reactors: so far regulators have cleared only five to go back online.

5. Researchers simulate helium bubble behavior in fusion reactors

August 6, 2015

http://phys.org/news/2015-08-simulate-helium-behavior-fusion-reactors.html

One of the most important challenges for successful commercialization of fusion power is the development of materials that can tolerate the extreme conditions of elevated temperatures and high particle flux of hydrogen isotopes and helium present in fusion reactors. Researchers designing the ITER international fusion reactor plan to use tungsten—one of the toughest materials known. A LANL team performed simulations to understand more fully how tungsten behaves in such harsh conditions, particularly in the presence of implanted helium that forms bubbles in the material. The journal *Physical Review Letters* published the team's research. Insight into the interactions between helium bubbles and tungsten could enable predictions of the evolution of tungsten over time in a fusion reactor.

Significance of the research

ITER is a large-scale, international scientific experiment in France that aims to demonstrate the viability of fusion energy, the same process that powers stars. Scientists will use two hydrogen isotopes, deuterium and tritium, to create a plasma at very high temperatures—between 10 million and 100 million degrees kelvin. The deuterium and tritium will collide in this extreme environment, fuse together to form a helium atom, and release a very energetic neutron.

As these helium particles bombard the tungsten wall, they form clusters within the material. When enough helium atoms are bunched together, they can "knock out" a tungsten atom from its normal position to form a nanoscale cavity within the tungsten. This acts as the nucleus of a helium bubble that can then grow very large, reducing the durability of the material. These bubbles also serve as traps for tritium, which reduces the amount of tritium available for the fusion reaction and introduces a radiological hazard. In addition, helium bubbles cause the tungsten surface to develop a fuzz-like nanostructure, which might erode into the plasma, degrade its quality, cool the fusion reaction and make it far more difficult to maintain.

The Los Alamos research is the first atom-based simulation of helium bubble growth at an appropriate rate for understanding bubble formation in fusion plasma facing materials in ITER. The new models revealed the impact of competing processes on helium bubble formation in plasma-exposed tungsten. The research demonstrated rate effects on bubble size, shape, pressure, and surface damage. These are critical features for predicting the response of tungsten under fusion conditions.

Research achievements

The Laboratory researchers combined accelerated molecular dynamics (AMD) with leadership-class computing to simulate the evolution of helium bubbles at helium implantation rates relevant for the conditions at ITER. The team used the Parallel Replica (ParRep) method, developed at Los Alamos, to achieve a drastic speedup in computing. The scientists examined the growth of helium bubbles in tungsten for growth rates spanning six orders of magnitude.

The team's simulations revealed two growth regimes of the helium bubbles, which affect the surface damage of tungsten. At the high helium implantation rates typical of previous calculations, the tungsten atoms surrounding the bubble do not have time to respond to the accumulated pressure. This results in highly overpressurized bubbles that grow to large sizes and burst violently upon reaching the surface of the material. In contrast, once the helium implantation rate is reduced to more realistic values consistent with the conditions expected at ITER, the tungsten atoms pressed against the bubble's surface can diffuse around the bubble. This phenomenon leads to a smaller bubble when it ultimately bursts. This lower helium implantation rate, which is only available via the AMD simulations, allows the tungsten atoms to respond to the pressure within the bubble. This process directs the bubble towards the surface and results in the bubble being smaller when it bursts. The results indicate that the evolution of damage in tungsten is very sensitive to how the bubbles grow.

Explore further: Researchers discover the cause of irradiation-induced instability in materials surfaces

More information: "Competing Kinetics and He Bubble Morphology in W." *Phys. Rev. Lett.* 114, 105502 – Published 11 March 2015. dx.doi.org/10.1103/PhysRevLett.114.105502

6. Investing in Europe's bright future in fusion

The EU-funded FUSENET project created new learning opportunities for Europe's future fusion scientists by developing educational materials, organising internships and bringing academia and industry closer together. While the project may be officially over, the concept has been kept very much alive through the ever-expanding FUSENET Association.

http://ec.europa.eu/research/infocentre/article_en.cfm?id=/research/star/index_en.cfm?p=ss-fusenet&calledby=infocentre&item=All&artid=35337&caller=AllHeadlines

"We currently have 55 paying members and are looking to get industry more involved," says FUSENET Association chairman Roger Jaspers from

Eindhoven University of Technology, the Netherlands. “They can tell us what competences and skills they need, and provide us with internships and training on the job, which is beneficial for all. We want everyone involved in fusion to be a member.”

Reaching for the stars

Nuclear fusion is an advanced method of power generation, whereby two lighter atomic nuclei fuse to form a heavier nucleus. This process, which powers the sun and every star in the universe, releases incredible amounts of energy. Achieving controlled fusion on Earth could provide civilisation with a sustainable, emission-free and low-cost energy source. So what’s the catch? For a start, the technology remains to be proven on a commercial scale and no commercial exploitation is expected before the second half of this century.

Nonetheless, there is growing consensus that fusion is the energy source of the future, and that if Europe is serious about it, then the time to invest is now. This is not just a question of investing billions in demonstration plants and experiments; investment must also be made to ensure that Europe has the knowledge and expertise to fully participate in the coming fusion revolution.

Fusing European knowledge

“At the start of the FUSENET project, no university had comprehensive expertise, or its own fusion programme,” explains Jaspers. “But add up the expertise all over Europe and you have a sizeable nucleus. Only together do we have sufficient resources and people. Furthermore, spending money on students is an efficient investment; a few thousand euros can go a long way.”

During the project’s five-year cycle, joint educational activities such as workshops and summer schools were organised, while educational tools such as hands-on laboratories, web-based course material and a fusion technology high school textbook were developed. The project also brought universities together in order to develop common academic criteria for awarding Master's and Doctoral certificates in fusion, in order to achieve consistent excellence. In the past year, ties with industry have been strengthened and the first internships arranged.

“The project website provides a portal to all fusion education in Europe, and offers educational materials and activities organised by educational level,” “says Jaspers. The project has more than achieved its goals.”

There are challenges ahead, but the future of fusion looks bright. The sheer complexity and investment-intensive nature of the technology means that cooperation is vital. China, the EU, India, Japan, Korea, Russia and the United States have come together to prove the viability of fusion through the ITER project (‘Iter’ is Latin for ‘The Way’). The goal is to build an operational experimental fusion reactor, which would later lead to the development of a full-scale demonstration power plant.

The FUSENET project was carried out very much in this cooperative spirit, pooling knowledge and skills that could not be provided by one single country. The FUSENET Association ensures that this legacy lives on, and will play an important role in training the next generation of fusion scientists and engineers.

If Europe – and indeed the world – is to succeed in quenching its insatiable thirst for energy in a sustainable and environmentally friendly manner, then patience, far-sighted investment and collaboration are required. The ongoing success of FUSENET is very much testament to this.

Project details

Project acronym:FUSENET
Participants: Netherlands (Coordinator), Portugal, France, Austria, Germany, Belgium, Czech Republic, Denmark, Finland, Hungary, Italy, Poland, Bulgaria, Romania, Spain, Switzerland, UK, Greece
Project Reference N° 224982
Total cost: €2 478 290,8
EU contribution: €2 000 000
Duration: October 2008 - September 2013

7. Holding the sun in bottle

http://www.koreatimes.co.kr/www/news/nation/2015/07/197_183278.html
By Steven Charles Cowley

LONDON — This December, world leaders will gather in Paris for the United Nations Climate Change Conference, where they will attempt — yet again — to hammer out a global agreement to reduce greenhouse-gas emissions. Despite the inevitable sense of déjà vu that will arise as negotiators struggle to reach a compromise, they must not give up. Whatever the political or economic considerations, the fact remains: if global temperatures rise more than 2˚C from pre-industrial levels, the consequences for the planet will be catastrophic.

But the challenge does not end with reducing emissions. Indeed, even if we make the transition to a cleaner world by 2050, we will need to determine how to meet a booming global population's insatiable appetite for energy in the longer term — an imperative that renewables alone cannot meet. That is why we need to invest now in other technologies that can complement renewables, and provide reliable electricity for many centuries to come. And one of the most promising options is nuclear fusion — the process that powers the sun and all stars.

Brought down to earth, nuclear fusion — a process fueled primarily by lithium and deuterium (an isotope of hydrogen), both of which are plentiful in seawater and in the earth's crust —could provide a major source of low-carbon energy. A fusion power station would use only around 450 kilograms of fuel annually, cause no atmospheric pollution, and carry no risk of accidents that could lead to radioactive contamination of the environment.

But, while the fusion process has produced some energy (16 million watts of it, to be specific), scientists have yet to create a self-sustaining fusion "burn." Indeed, unlike nuclear fission, which went from the laboratory to the power grid within two decades, fusion has proved a tough nut to crack.

The problem is that fusion involves joining two positively charged nuclei — and, as basic science shows, same-sign charges repel each other. Only at extremely high temperatures — over 100 million degrees Celsius, or almost ten times hotter than the sun — do the nuclei move so rapidly that they overcome their repulsion and fuse.

Scientists have spent the last 60 years trying to figure out the best way to create these conditions. Today, the frontrunner is a device known as a "tokamak," a magnetic bottle in which the fuel, held at 100-200 million degrees Celsius, fuses, unlocking huge amounts of energy.

Of course, holding the sun in a bottle is no small challenge, especially when one considers that the systems must be engineered so that they can create electricity for a price consumers are willing to pay. But in a sunny corner of southern France, a global megaproject is coming together that will, for the first time, test the technology on an industrial scale, creating the first controlled fusion burn.

Everything about the so-called "ITER reactor" is big. It will be heavier than three Eiffel Towers; the material for its superconducting magnets would stretch around the equator twice; and it has a price tag of more than €15 billion ($16.8 billion), making it one of the largest international science endeavors in history. The ITER partners — China, the European Union, India, Japan, Russia, South Korea, and the United States — represent half the world's population. And, if it is successful, the reactor will produce half a gigawatt of fusion power and open the way for commercial reactors.

But the tokamak is not the only game in town. Other designs are emerging to join the race for fusion power. Lawrence Livermore National Laboratory's National Ignition Facility in California is getting impressive results by firing high-powered lasers at capsules of fuel, crushing the particles together to trigger fusion reactions.

Elsewhere, particularly in the US, privately funded fusion ventures are springing up like mushrooms, each with its own concept for what some call the Holy Grail of energy. As the most advanced design, the tokamak still looks like the safest bet, but the competition from its rivals can only spur further innovation and progress.

Some discourage investment in nuclear fusion, claiming that, given how far from being market-ready the technology is, our financial resources are better allocated to tried and tested energy options. The critics have a point: given that fusion can be carried out only on a large scale, its investment requirements are considerable.

In the 1970s, American researchers estimated that getting fusion power on the grid would demand investment of $2-3 billion annually in research and development until anywhere from 1990 to 2005 (depending on the amount of effort applied). They also estimated a minimum level of investment, below which funding would never be sufficient to build a fusion power plant. Nuclear fusion research budgets have remained below that line for 30 years.

But fusion's potential is simply too great to give up. And, in fact, the progress that has been made in recent years — despite the lack of adequate investment — belies the naysayers. Machines all over the world are reaching fusion temperatures and extending our technological capabilities. The ITER experiment, when it starts up in the early 2020s, will embody those advances, achieving the long-awaited fusion burn — and place us just one step away from the ultimate goal of getting fusion power on the grid in an affordable manner.

Without nuclear fusion, future generations' energy options will be severely limited — creating a serious problem for developed and developing countries alike. Lev Artsimovich, the tokamak's inventor, said that "fusion will be ready when society needs it." One hopes that he is right. But, rather than depending on fusion researchers to defy the odds, the world should step up investment in the technology. Our future may depend on it.

Steven Charles Cowley is CEO of the UK Atomic Energy Authority, Professor of Physics at Imperial College London, Head of the EURATOM / CCFE Fusion Association, and President-Elect of Corpus Christi College at Oxford University. For more stories, visit Project Syndicate (www.project-syndicate.org).

8. Japan reactor restart finally puts the country on the road to recovery

World Nuclear Association Press Release
Issue Date: 11 August 2015
http://world-nuclear.org/Press-and-Events/Press-Statements/Japan-reactor-restart-finally-puts-the-country-on-the-road-to-recovery/

"Today Japan has reminded the world that it is committed to creating a better future" - said Agneta Rising, Director General of the World Nuclear Association in response to the restart of the Sendai unit 1 nuclear reactor. This is the first of 43 operable Japanese nuclear reactors which are mostly expected to start coming back online over the coming months and years.
"This is a hugely important step which sets the country firmly on the path to restoring its trade balance and regaining energy independence, as well as reducing emissions" continued Rising.
For almost two years now not a single nuclear power reactor in Japan has operated as the nation's fleet was progressively idled following the Fukushima Daiichi nuclear accident. Although the accident has not led to any measurable radiation health impacts and is not expected to, it led to a long term public evacuation, heightened public fears and new safety requirements for all Japan's remaining nuclear facilities(1).
"The process of regaining public trust takes a big step forward today. It is completely understandable that people's faith in nuclear technology was shaken by the events of 11 March 2011, but now the Japanese people need to see their reactors performing efficiently and reliably with operators fully committed to protecting public health and the environment. It is important that they are reminded of the key role nuclear energy has traditionally played in supporting industry, keeping bills down, and keeping Japan secure."

"The global nuclear industry stands united in welcoming news of the first Japanese reactor restart. The Japanese nuclear industry is an important part of the global industry and we have to a degree shared their hardships."
"The restart of Sendai unit 1 puts Japan on the road to recovery" said Rising. "Going forward, it is essential that the nuclear industry works harder at building better relationships with the public as well as improving our performance and future technology offerings."

9. Keel-laying for new US nuclear ship

24 August 2015

The keel for the US Navy's second Gerald Ford-class nuclear-powered aircraft carrier, the *John F Kennedy,* has been laid at a ceremony in Newport News, Virginia.

http://www.world-nuclear-news.org/ON-Keel-laying-for-new-US-nuclear-ship-2408157.html

The keel laying is the symbolic beginning of a ship's construction and the ceremony saw the ship's sponsor, Caroline Kennedy, declare the keel "truly and fairly laid". Kennedy, daughter of the 35th US President after whom the ship is named, is the US Ambassador to Japan and made her address to the ceremony by video link.

The vessel, numbered CVN79, is being built by Newport News Shipbuilding, a division of Huntington Ingalls Industries. More than 450 of the ship's 1100 structural units have already been constructed since the first cut of steel in 2010.

The first vessel of the class, the *Gerald R Ford* (CVN78), will be the first US aircraft carrier to be entirely electrically powered. Its two Bechtel A1B reactors are two to three times as powerful as the A4W units in the USA's Nimitz-class aircraft carriers. Huntington Ingalls describes it as "the most efficient aircraft carrier ever designed", requiring less manpower to operate and saving the US Navy more than $4 billion over the ship's 50-year life. The *Gerald R Ford* is due to be delivered to the US Navy in 2016.

Researched and written
by World Nuclear News

10. Enel in talks with EPH over Slovenské Elektrárne stake

24 August 2015

http://www.world-nuclear-news.org/C-Enel-in-talks-with-EPH-over-Slovenske-Elektrarne-stake-2408154.html

24 August 2015

Italian utility Enel announced today that it is in exclusive negotiations with Czech energy company Energetický a

Průmyslový Holding (EPH) to sell its 66% stake in Slovak nuclear power producer Slovenské Elektrárne. Enel said it may sign a binding share purchase agreement with EPH "in the coming weeks".

Enel paid €840 million ($1.1 billion) in 2006 for its 66% stake in Slovenské Elektrárne and, as part of the transaction, it agreed to complete construction of two additional reactors at the Mochovce nuclear power plant. The Italian utility launched a program in July last year to sell its holdings in Romania and Slovakia, including its stake in Slovenské Elektrárne. Divestment of these assets is part of a €6 billion ($8 billion) asset sale begun by Enel in 2013 to reduce the group's financial debt.

At the end of July, Enel announced plans to sell its stake in Slovenské Elektrárne in two stages - through the sale of a minority stake by the end of this year and the remainder once construction of two nuclear power units at Mochovce nuclear power plant in Slovakia has been completed. The Slovak government owns the remaining 34% in the country's biggest power producer.

In a presentation to analysts of the Italian utility's financial results for the first six months of this year, Enel CEO Francesco Starace said completion of units 3 and 4 at Mochovce are now expected about one year later than previously planned - in 2017 and 2018, respectively.

In addition to the offer from EPH - the second largest electricity producer in the Czech Republic - for some or all of its stake in Slovenské Elektrárne, Enel also received a final offer from Mol Nyrt, a Hungarian-Slovak consortium of MVM Group and the refinery Slovnaft. Finland's Fortum and China National Nuclear Corporation had also reportedly been interested in buying a stake.

Researched and written
by World Nuclear News

11. Disposal beats MOX in US comparison

21 August 2015

America is reconsidering how it will dispose of 34 tonnes of plutonium as the previous plan involving a MOX plant has been said to be twice as costly as a dilution and disposal option in a leaked Department of Energy (DOE) report.

http://www.world-nuclear-news.org/WR-Disposal-beats-MOX-in-US-comparison-2108151.html

America is reconsidering how it will dispose of 34 tonnes of plutonium as the previous plan involving a MOX plant has been said to be twice as costly as a dilution and disposal option in a leaked Department of Energy (DOE) report.

The plutonium arises from a June 2000 nuclear weapons reduction agreement with Russia under which both countries would put 34 tonnes of plutonium beyond military use. Russia opted to use its plutonium as fuel for fast reactors generating power at Beloyarsk. The USA, meanwhile, decided to build a mixed-oxide (MOX) nuclear fuel plant at Savannah River, where the plutonium would be mixed with uranium and made into fuel for light-water reactors. The design is similar to Areva's Melox facility at Marcoule, but modified to handle metal plutonium 'pits' from US weapons and their conversion from metal to plutonium oxide. It is this part of the process that has been problematic. Construction started in 2007 with an estimated cost of $4.9 billion but work ran into serious trouble before being 'zeroed' in the DOE's 2014 budget, putting development on ice.

The Union of Concerned Scientists yesterday published what it said was an unreleased DOE report that compared the cost of completing the MOX plant to other options. Use in fast reactors was considered briefly, but with this technology not readily available in the near term, the prime comparison was against a 'dilution and disposal' option which would see the plutonium mixed with inert materials and disposed of in the Waste Isolation Pilot Plant, or WIPP, in New Mexico.

Despite being 60% built, the MOX plant still needs some 15 years of construction work, said the leaked report, and then about three years of commissioning. Once in operation the plant would work through the plutonium over about 10 years with this 28-year program to cost $700-800 million per year - a total of $19.6-22.4 billion on top of what has already been spent. Not only is the price tag very high, but the timescale is too long: the report said this would not meet the disposal timeframe agreed with Russia.

The cost of the MOX plant could not be mitigated by income from sales of the MOX fuel because the regulatory process to gain approval to use MOX would be too burdensome for a commercial utility. The report said "it may be unlikely" that even a utility in a regulated market where fuel costs are passed on to consumers would "bear the risk of MOX fuel even if it is free".

Dilution and disposal would cost $400 million per year, said the report, "over a similar duration" as MOX, working out at close to half the cost. Other advantages for dilution and disposal are that it requires no new facilities to be created or decommissioned after use, although the increase in WIPP disposal means "it may eventually become desirable to explore expansion of WIPP's capacity" beyond currently legislated limits. This unique geologic disposal facility was said to be of "tremendous value to both DOE and the State of New Mexico".

Researched and written
by World Nuclear News

12. Scientists offer explanation for electron heat loss in fusion plasma

by Staff Writers
Princeton NJ (SPX) Aug 05, 2015
http://www.spacedaily.com/reports/Scientists_propose_an_explanation_for_puzzling_electron_heat_loss_in_fusion_plasmas_999.html

Creating controlled fusion energy entails many challenges, but one of the most basic is heating plasma - hot gas composed of electrons and charged atoms - to extremely high temperatures and then maintaining those temperatures.

Now scientist Elena Belova of the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) and a team of collaborators have proposed an explanation for why the hot plasma within fusion facilities called tokamaks sometimes fails to reach the required temperature, even as researchers pump beams of fast-moving neutral atoms into the plasma in an effort to make it hotter.

The results, published in June in Physical Review Letters, could lead to improved control of temperature in future fusion devices, including ITER, the international fusion facility under construction in France to demonstrate the feasibility of fusion power. This work was supported by the DOE Office of Science (Office of Fusion Energy Sciences).

The researchers focused on the puzzling tendency of electron heat to leak from the core of the plasma to the plasma's edge. "One of the largest remaining mysteries in plasma physics is how electron heat is transported out of plasma," said Jon Menard, program director for PPPL's major fusion experiment, the National Spherical Tokamak Experiment-Upgrade (NSTX-U), which is completing a $94 million upgrade.

Belova hit upon a possible answer while performing 3D simulations of past NSTX plasmas on computers at the National Energy Research Scientific Computing Center (NERSC), in Oakland, California. She saw that two kinds of waves found in fusion plasmas appear to form a chain that transfers the neutral-beam energy from the core of the plasma to the edge, where the heat dissipates.

While physicists have long known that the coupling between the two kinds of waves - known as compressional Alfven waves and kinetic Alfven waves (KAWs) - can lead to energy dissipation in plasmas, Belova's results were the first to demonstrate the process for beam-excited compressional Alfven eigenmodes (CAEs) in tokamaks.

Her simulations showed that when researchers try to heat the plasma by injecting beams of energetic deuterium, a form of hydrogen, the beams excite CAE waves in the plasma's core. Those waves then resonate with KAW waves, which occur primarily at the plasma's edge. As a result, the energy is transported from the injection site deep within the plasma to the plasma's edge.

"Originally, when scientists found that the electron temperature wouldn't go up with increased beam power, everybody assumed that the electrons were getting heated at the plasma's center and then were somehow losing that heat," Belova said. "Our explanation is different. We propose that part of the beam energy goes into CAEs and then to KAWs. The energy then dissipates at the plasma's edge."

The simulations provided a broad perspective. "In simulations you can look everywhere in a plasma," Belova said. "In the experiments, on the other hand, you are very limited in what and where you can measure inside the hot plasma."

Belova's findings reflect the growing collaboration between theoretical and experimental research at the Laboratory. Her results could enhance understanding of electron energy transport in experiments on the NSTX-U, said

Amita Bhattarcharjee, head of the Theory Department at PPPL.
Belova plans to run more simulations to determine whether the mechanism she identified is the primary process that modifies the electron heating profile. She will also look for ways in which physicists can avoid this wave-induced change in the profile. In the meantime, she is driven by her desire to learn more physics. "We want to understand how these waves are excited by the beam ions," she said, "and how to avoid them in the experiments."

13. Going Nuclear: The Fusion Race Is Heating Up. Will Anyone Cross the Finish Line? (Video)

BY JAMES TEMPLE *ethics bio articles*
http://recode.net/2015/07/01/going-nuclear-the-fusion-race-is-underway-but-will-any-startups-cross-the-finish-line-video/

A

growing number of private players believe they can commercialize fusion energy within a decade, promising a carbon-free energy source with near-limitless fuel, potentially in time to ease the mounting risks of climate change.
A team at Lockheed Martin's Skunk Works revealed late last year that they're at

work on a truck-sized fusion reactor. Amazon's Jeff Bezos and others have plugged money into General Fusion in Burnaby, British Columbia. Microsoft co-founder Paul Allen and Venrock have invested in Tri-Alpha Energy, a secretive effort near Irvine, Calif. And Peter Thiel's Mithril and Y Combinator have funded a Redmond, Wash., startup called Helion Energy.

But the billions of government dollars and decades of research invested in replicating the power source of the sun have, to date, largely resulted in missed deadlines, cost overruns and incremental progress.

As the old joke goes: Fusion power is thirty years away — and always will be.

So there's considerable skepticism in the scientific community that these private upstarts can achieve such ambitious timelines — or whether they can pull off fusion at all.

"It's probably a better bet than that Nigerian prince that keeps emailing me, but I would not invest my money in it," said Edward Morse, a professor in UC Berkeley's nuclear engineering department.

He said that fusion researchers have tried most of these alternative approaches and simply failed to produce the results needed to justify continued investment.

Morse and others in the field believe the more promising paths today remain the massive, government-backed efforts, notably ITER, a so-called tokamak reactor under construction in southern France, which confines plasma fuel in the shape of a giant donut. But the international scientific collaboration is years behind schedule and estimated costs have more than tripled to around $20 billion.

It would be difficult to overstate the promise of successfully commercializing fusion. It is free from the meltdown dangers of fission, potentially far more efficient than renewables like solar and wind — and unlike fossil fuels, it wouldn't pump out the greenhouse gases that are warming the planet.

Where nuclear fission splits atoms, fusion pushes two nuclei together, releasing energy in the process.

"It's probably a better bet than that Nigerian prince that keeps emailing me, but I would not invest my money in it."
– Edward Morse, UC Berkeley professor

A single gram of a fusion fuel like deuterium oxide is potentially equivalent to 10 tons of coal, according to Helion. That's enough fuel to power a home for a year, all packed into a vial no bigger than your pinky.

David Kirtley, chief executive of Helion, believes his startup can build a compact prototype reactor that generates more energy than it consumes within the next three years, achieving what's known as "scientific gain," by pursuing an approach known as magneto-inertial fusion. It relies on magnetic fields to hold and compress the plasma fuel.

"We think that we're transitioning this technology away from billion-dollar scale government programs, to these small private fusion efforts where innovation can build on all of those years of R&D and science, to then move forward with small, distributed fusion systems," he said.

To learn more, watch the video above.

Update: This story has been updated to clarify that Helion hopes to achieve what's known as "scientific gain" within three years, not "ignition," which means a self-sustaining fusion reaction.

14. Measuring the National

Ignition Facility's inferno

June 11, 2015 by Breanna Bishop

http://phys.org/news/2015-06-national-ignition-facility-inferno.html

The smooth blue sphere of the National Ignition Facility's (NIF) target chamber bristles with diagnostics—nuclear, optical and X-ray instruments that together provide some 300 channels for experimental data. These diagnostics provide vital information to help NIF scientists understand how well an experiment performed.

Two of these diagnostics, known as Dante 1 and Dante 2, are pressed into service for nearly every shot. These broadband, time-resolved X-ray spectrometers measure the time-dependent soft X-ray power produced by the NIF lasers interacting with the hohlraum—the small gold cylinder that holds the NIF target capsule. The X-rays heat and ablate the outer surface of the capsule and drive the capsule's rocket-like implosion. The resulting data are used to calculate the radiation spectrum and infer the temperature of the radiation field inside the hohlraum. This information can be directly compared to hohlraum simulations to determine if the hohlraum and laser pulse are performing as designed.

"Dante is one of the workhorse diagnostics of NIF—it participates in almost every shot," said Alastair Moore, responsible scientist for Dante. "Even when a hohlraum is not used, it is one of the few absolutely calibrated soft X-ray diagnostics that can provide absolute measurements of the conversion efficiency of laser light into X- rays."

Each Dante diagnostic measures the voltage produced by 18 filtered X-ray diodes. Each diode is filtered to record the X-ray power in a specific part of the spectrum. Spectral ranges are controlled by filters, metallic mirrors and X-ray diode material. Dante 1 has five channels with mirrors, and Dante 2 has eight mirrored channels.

Because Dante is an absolutely calibrated system, every component must be calibrated and tracked, making it one of the more challenging diagnostics to maintain and operate. According to Moore, the calibration of each component typically involves approximately 100 measurements.

"On the two Dante systems, we maintain approximately 10 different filter configurations, each of which contains about 45 calibrated filters," he said. "The filters are pretty fragile components and debris from shots can damage them over time, requiring a continual replenishing of the stock of components."

In addition to the filters, approximately 50 X-ray diodes are calibrated on a cyclical basis and maintained along with about 20 grazing incidence X-ray mirrors. This adds up to an inventory of thousands of components that must be tracked, maintained and verified.

The Dante team recently transitioned to a new way of operating the diagnostic filter configurations, introducing standardized sets. This adaptation significantly reduced the overhead costs associated with building filter configurations and also reduced the error bars on the measurements, making better shot-to-shot comparisons possible. The team also is in the process of replacing the 18 oscilloscopes used to record the X-ray diode signals and automate the setup, reducing manual interactions required for each shot.

Looking to the future, the team is exploring a modification to some of the channels that measure the part of the spectrum containing M-band radiation from the hohlraum, an important measurement for inertial confinement fusion.

"This radiation can preheat the capsule significantly, resulting in an increase in instability growth," Moore said. "The upgrade will add multi-layer X-ray mirrors to these channels to provide a better constrained X-ray bandpass and a more accurate measurement of the power in this region."

The forerunner of the Dante diagnostic originated in the era of underground nuclear weapons testing, where it was developed for the same purpose as it is used today—to measure the absolute X-ray power produced. A multi-institutional team with members from Lawrence Livermore, Los Alamos and Sandia national laboratories, the UK's Atomic Weapons Establishment, National Securities Technologies and General Atomics contributed to adapting the diagnostic to its current use.

Explore further: Laser sets records for neutron yield, laser energy

Provided by: Lawrence Livermore National Laboratory

15. IEA sets out pillars for success at COP21

Report offers strategy for delivering a peak in energy emissions by 2020

15 June 2015 London

http://www.iea.org/newsroomandevents/pressreleases/2015/june/iea-sets-out-pillars-for-success-at-cop21.html

A peak in global energy-related emissions could be achieved as early as 2020 and at no net economic cost, the International Energy Agency said on Monday in its new *World Energy Outlook* Special Report on Energy and Climate Change. The Agency showed how to achieve an early peak in emissions as one of four key pillars that it believes are needed to make the upcoming UN climate talks a success, from an energy perspective.

The world is at a critical juncture in its efforts to combat climate change, with momentum building towards the 21st UN Conference of the Parties (COP21) in Paris in December 2015. World greenhouse-gas (GHG) emissions from energy production and use are double the level of all other sources combined, meaning that action to combat climate change must come first and foremost from the energy sector. The IEA proposes that the following four key pillars are needed to make COP21 a success, from an energy perspective:

1. Peak in emissions – set the conditions to achieve an early peak in global energy-related emissions.
2. Five-year revision – review national climate targets regularly, to test the scope to raise ambition.
3. Lock in the vision – translate the world's climate goal into a collective long-term emissions goal.
4. Track the transition – establish a process for tracking achievements inthe energy sector.

"As IEA analysis has repeatedly shown that the cost and difficulty of mitigating greenhouse-gas emissions increases every year, time is of the essence," said IEA Executive Director Maria van der Hoeven. "It is clear that the energy sector must play a critical role if efforts to reduce emissions are to succeed. While we see growing consensus among countries that it is time to act, we must ensure that the steps taken are adequate and that the commitments made are kept."

A peak in global energy-related emissions could be achieved as early as 2020 if governments implement just five key policy measures, as shown in the IEA's "Bridge Scenario". This major climate milestone is possible utilising only proven technologies and policies, and without changing the economic and development prospects of any region. Intended as an effective bridge to further action, the five measures focus on:

- Increasing *energy efficiency* in the industry, buildings and transport sectors
- Reducing the use of the *least-efficient coal-fired power plants* and banning their construction
- Increasing investment in *renewable energy technologies* in the power sector from $270 billion in 2014 to $400 billion in 2030
- Gradual phasing out of *fossil-fuel subsidies* to end-users by 2030
- Reducing *methane emissions* in oil and gas production

For countries that have submitted climate pledges for COP21, the proposed strategy identifies possible areas for over-achievement. For those that have yet to make a submission, it sets out a pragmatic baseline.

The IEA report highlights the need for climate pledges for COP21 to be viewed as the basis from which to create a "virtuous circle" of increasing ambition, and advocates, as its second pillar, a five-year review cycle to test the scope for further action. Both the situation and the solutions are evolving rapidly: the world's shrinking "carbon budget" means that any delay in taking action can be costly, while the pace of energy sector innovation means that a five-year review would allow national targets to keep up with events and help build investor confidence.

As its third pillar, the IEA recommends that the goal of keeping the increase in long-term average global temperatures to below two degrees Celsius (2 °C) also be expressed as a long-term greenhouse-gas emissions target, making it more straightforward to apply in the energy sector. Doing so would help anchor future expectations, guide investment decisions, provide an incentive to develop new technologies, drive needed market reforms and spur the implementation of strong domestic policies, such as carbon pricing – all of which are necessary to meet the 2 °C goal.

The final pillar proposed by the IEA report is that the COP21 agreement establish a strong process for tracking progress in the energy sector. Tracking national progress would both provide clear evidence of results, reassuring the international community that others are acting diligently, and identify countries that are struggling with implementation, enabling assistance to be provided if needed. In recognition of this need, the IEA report sets out appropriate metrics to monitor energy sector decarbonisation.

“Any climate agreement reached at COP21 must have the energy sector at its core or risk being judged a failure,” said IEA Chief Economist Fatih Birol. “Climate pledges submitted for COP21 are an important first step to meeting our climate goal, and our report shows that they will have a material impact on future energy trends.”

Collectively, countries accounting for around two-thirds of global energy-related emissions have either formally submitted their climate pledges for COP21 (known as “Intended Nationally Determined Contributions [INDCs]”) or have signalled their possible content (such as China). A first assessment reveals these pledges will have a positive impact on future energy trends, but fall short of the major course correction required to meet the 2 °C goal.

The assessment of the INDCs shows that the growth in global energy-related emissions slows but does not peak by 2030. The link between economic growth and emissions weakens significantly, but is not broken: the economy grows by 88% from 2013 to 2030 and energy-related carbon dioxide emissions by 8%. Renewables are the leading source of electricity by 2030, but inefficient coal-fired power generation capacity declines only slightly. Such findings underline the need for ambitious national pledges for COP21 that can act as a solid base upon which to build stronger action, such as those enabled by a transfer of resources (technology or finance).