ITER Forum website Update 2/17

B.J.Green (21/2/17)

1. Indian scientists exploiting healing powers of plasma

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http://economictimes.indiatimes.com/news/science/indian-scientists-exploiting-healing-powers-of-plasma/articleshow/56715628.cms

From Pallava Bagla

GANDHINAGAR: On the banks of the Sabarmati river in Gandhinagar sandwiched between an Amul Dairy and a hospital is a unique institute which plays neither with solid, liquid or gas but with the fourth state of matter, called plasma.

Today scientists at the Institute for Plasma Research (IPR) are using this little known fourth state of matter for healing not only humans but also the earth.

Plasma is that unique state of matter where charged ions abound in gaseous form but since the whole mass is charged they behave uniquely unlike any other known form of matter.

The most intense and dense state of plasma that we see every day is the Sun, here hot gasses stripped of electrons survive in an exceptional state and one of the consequences of that giant ball of plasma is the release of solar energy that literally powers life on Earth. So in a way, plasma indeed has a life giving property.

Mostly plasmas are formed at very high temperatures but scientists can also produce plasmas at low temperatures and the cool plasma is used to cure human fungal infections and a variant is also used to treat a type of very warm wool called Angoora that produces some of the warmest woollen clothing.

In addition, high temperature plasmas are being deployed to destroy toxic hospital and organic waste, so plasmas are helping heal the Earth.

The Institute of Plasma Research, with an annual budget of Rs 500 crore, is best known for trying to harness that elusive eternal fruit of energy called fusion power, where two atoms are fused together and the energy they release can be used to generate electricity.

At IPR, using giant machines called 'tokamaks' some 700 workers are engaged in an effort to create a transient mini-Sun. Today using giant magnets and huge electrical fields, they can simulate the conditions that prevail on the Sun for a tiny-tiny fraction of a second. The hope is that if the same can be created on a perpetual basis which the boffins like to call a steady state, then harnessing fusion power would be one step closer.

Today one can only admire the Sun to benefit from its boundless energy. The high-tech plasma institute is best known as that great centre of learning that is helping India partner in the International Thermonuclear Experimental Reactor (ITER) being constructed in France, a USD 14 billion grandest of atomic reactors that when fully functional will help deliver clean fusion power hopefully by 2050.

This is a dream project funded and run by seven member entities, the European Union, India, Japan, China, Russia, South Korea, and the USA.

But today in an industrial shed of IPR scientists at the Facilitation Centre for Industrial Plasma Technologies, work is going on to meet the immediate societal needs. One technology they are testing is how to use low temperature plasma to treat fungal infections and to help a dentist clean dirty teeth.

Cold plasma jets have been developed using argon gas and these plasma streams are directly applied to the infected spot and within a few sittings and without the application of any anti-fungal creams the infection just withers away, the first clinical trials are being conducted in Kolkata.

Being able to touch and feel this elusive fourth state of matter is a unique experience, reluctantly I put my finger on the plasma jet not knowing what would be the outcome, a mild tingling is what one feels as one pushes the finger into the intense light of the plasma jet. Having experienced solids, liquids and gasses this was the first time I actually touched and felt the fourth state of matter!

Biomedical waste is a particularly nasty form of refuse that gets generated in hospitals and laboratories, high in organic matter, the only way to dispose this often highly infectious waste is to incinerate or burn it at high temperature. The infectious material can indeed get consumed but it produces a carcinogenic fume rich in dioxins, hence simple burning can often lead to a downstream environmental catastrophe.

Scientists at IPR figured out that if you destroy organic waste in oxygen-starved conditions by using high temperature plasma, the waste could directly be converted into relatively environmentally benign molecules like methane, carbon mono-oxide, hydrogen and water. The process called plasma pyrolysis is relatively expensive but can help heal the earth.

Last week, when Prime Minister Narendra Modi inaugurated India International Exchange at the Gujarat International Finance Tec-City or GIFT City in Gandhinagar that gives India extended trading hours, if he wanted he could have also visited the functional environment friendly organic waste disposal facility that operates using the ultra-modern plasma pyrolysis plant set up with the help of Indian scientists.

A waste to wealth innovation' is what Shashank Chaturvedi, Director of IPR, calls this an example of a "plasma-aided Swachh Bharat Abhiyan". Today the plant at the GIFT City can handle just 15 kilogrammes of waste per hour. Using a small furnace and graphite electrodes, hot plasma is produced which then destroys organic waste into harmless gases. In fact, in larger plants the waste gasses can then be used to generate heat and electricity.

Dr S Mukherjee, head of the tech transfer division of IPR, says the technology has been now been given a green signal by the Ministry of Environment and Forests and the waste stream for which plasma pyrolysis technology can be adopted include biomedical waste, municipal solid waste, industrial chemical waste, tyre waste, tannery waste, electronics waste and IPR has successfully demonstrated 11 systems in India.

It was a few months ago that the Central Pollution Control Board gave its permission that plasma pyrolysis could be used to safely dispose the worst quality of biomedical waste.

Chaturvedi says even as the world eagerly waits to see copious amounts of energy being produced from the fourth state of matter, plasma is indeed already helping heal man and matter.

2. Has Metallic Hydrogen Been Achieved For The First Time?

Alfredo Carpineti 26/01/17 19:34

http://www.iflscience.com/physics/metallic-hydrogen-achieved-for-the-first-time/

Researchers might have finally been able to produce metallic hydrogen, a complex and elusive state that was firstly theorized more than 80 years ago.

Dr Ranga Dias and Professor Isaac Silvera from Harvard University were able to achieve this impressive feat by cooling down hydrogen to 5.5 Kelvin (-268°C/-450°F), while compressing it to a staggering pressure of 4.8 million atmospheres. The breakthrough is reported this week in Science.

The incredibly high pressure was achieved by using diamond anvil cells. But it was not a straightforward approach. Scientists have been trying to get to this pressure for many years, and although they've almost got there, only now have scientists got the right set up.

"Metallic hydrogen was never made before because diamonds failed before a sufficiently high pressure was attained," Professor Silvera told IFLScience. "We do not use natural diamonds but rather synthetics which are very homogeneous, while naturals have inhomogeneities and internal defects and impurities."

In its standard form, hydrogen is a molecular gas with its atoms bound in pairs, each sharing an electron with the other. When hydrogen was placed between the anvils, the pressure mounts and things get weird.

At a pressure of 3.2 million atmospheres, hydrogen becomes opaque (hence the nickname black hydrogen) and is also a semiconductor. But only a much higher pressure can break the molecular bonds and create the metallic hydrogen phase. The gas appeared to turn into a metal, with the expected properties an atomic metal has. The two researchers believe metallic hydrogen is a solid, but the team wasn't able to confirm it experimentally.

Confirmation is, of course, key. While the team is very confident, others have cast doubt that what has been seen is actually the long

sought-after phase.
This peculiar phase of hydrogen was first predicted in 1935 by E. Wigner and H.B. Huntington, and since then achieving this has become the "holy grail of high-pressure physics". But Wigner and Huntington were wrong in their estimation of the necessary pressures. They thought metallic hydrogen could be achieved with a pressure of 250,000 atmospheres, almost 20 times smaller than what has been claimed by the Harvard researchers.
The ability to create metallic hydrogen would not just be a triumph of science for the sake of science. Understanding the metallic properties of the most abundant element in the universe has a multi-disciplinary impact.
Metallic hydrogen is thought to be metastable at room temperature after the pressure is removed, so it could be used in nuclear fusion. It is also believed to be a high-temperature superconductor, which would be an incredible breakthrough if confirmed. Even astronomy might benefit from this discovery – the core of Jupiter, Saturn, and exoplanets could be made of metallic hydrogen.

3. NRG begins testing special steel for Iter

1 February 2017

Nuclear Engineering International

http://www.neimagazine.com/news/newsnrg-begins-testing-special-steel-for-iter-5728844

NRG of the Netherlands said on 25 January that it has started irradiation testing Eurofer97 low-activation stainless steel that will be used in the Iter nuclear fusion reactor under construction at Cadarache in southern France. The steel will be used to contain the Iter reactor components in which tritium will be used.
The irradiation of two capsules with steel samples in the High Flux Reactor at Petten began in December 2016 and will continue up to early 2018. Two shorter irradiations will start in February and will last until September. The metal will then be removed from the reactor and transported to Studsvik in Sweden where it other tests will take place to ascertain the impact of irradiation, the brittleness of the materials, the microscopic changes that take place and the extent to which the strength characteristics are affected. The Swedish analysis should show whether the materials are suitable for use in the Iter core.

The Iter project is an international joint venture involving the European Union (EU), Japan, South Korea, China, India, the US and Russia. It is designed to produce 500MWe and should be operational by 2025.
Many components are still being developed, including the steel casing inside which tritium is produced by interaction with the neutron radiation generated in the fusion reaction. For this process, six different concepts have been developed globally, two of them in Europe. The most effective concept will ultimately be used in future nuclear fusion reactors. “China, for example, is also developing a module to produce tritium. So if one concept doesn’t work, there’s always an alternative,” explained NRG Project Manager Nora Klaassen.
NRG said this is the HFR’s second recent contribution to Iter. In September 2016, NRG started testing components of the first wall that will encase the 150m degree fusion process in the core. Now, together with Swedish company Studsvik NRG will characterise the Eurofer97 steel, which will be used to contain the Iter reactor component in which tritium will be produced. Eurofer97 is a specially developed low-activation steel, in which the composition is tailored such that long term radioactivity after exposure to radiation is significantly reduced. The test aims to demonstrate that Eurofer97 is sufficiently resistant against the radiation environment in Iter. During the tests, the steel will be exposed to the same neutron radiation and temperature as in the Iter plant.
Earlier, Fusion for Energy (F4E), The EU organisation responsible for Europe's contribution to Iter, signed a contract with Saarschmiede GmbH Freiformschmiede of Germany to deliver various Eurofer97 finished products. A total of approximately 27t will be manufactured in the form of special plates and bars of various thicknesses from 1.2 to 45mm. The completion of the manufacturing, testing operations and acceptance of the Eurofer finished products, storage and delivery is expected to take 17 months.

4. 5 Ground-breaking High-Tech Projects Underway in Rural France
https://theculturetrip.com/europe/france/articles/5-ground-breaking-high-tech-projects-underway-in-rural-france/

With unbelievable tech innovations in Paris being unveiled every other week – see our articles on flying taxis, a floating gym, and sewer-heated swimming pools for proof – it can be easy to fall into the kind of lazy thinking that believes

exciting, intelligent life ends at the périphérique. Oh, how wrong this would be. Below are just five astounding works of science and engineering taking place in the countryside across France.
See the article for the other 4, because here we reproduce only one!
The ITER nuclear fusion reactor

In the countryside outside Saint-Paul-lez-Durance, a Provençal town about an hour north of Marseille, thousands of scientists and engineers from 35 countries are working hard to recreate the sun right here on Earth.

ITER, the most sophisticated and expensive machine ever built, could help solve humanity's impending energy crisis. The flattened, 42-hectare site will be home to the world's largest tokamak, a ring-shaped device designed to test the feasibility of nuclear fusion as a large-scale, carbon-free energy source and provide a blueprint for future power plants.

Nuclear fusion involves the collision of hydrogen nuclei to form heavier helium atoms. The process releases enormous amounts of energy, without harmful emissions and with very little radioactive waste.

To achieve fusion, ITER will heat a cloud of hydrogen gas to 150 million degrees Celsius (a temperature

50% hotter than the sun's core) to form a collision-rich plasma that is controlled and confined by super-powerful magnets.

The energy produced by fusion events will be absorbed by the machine's walls as heat and, as with a conventional power plant, this will create steam and then electricity using turbines and generators, albeit on a much grander scale.

It is hoped that ITER will provide 500 megawatts of power, 10 times its predicted input.

5. A fusion fly-over

Posted on Jan 31, 2017 11:44 am

http://blog.physicsworld.com/2017/01/31/a-fusion-fly-over/

By Michael Banks
To the critics, a working fusion power plant is always 30 years away. But in the past decade, progress has been made at the construction site of the ITER fusion reactor in Saint-Paul-lez-Durance, France.
Ten years ago – on 29 January 2007 – preparation work began on ITER's home in the large stretch of national forest. Within two years, more than three million cubic metres of rocks and soil had been removed to level the site ready for the behemoth.
Expected to cost tens of billions of euros, ITER aims to show that it is technically feasible to get usable amounts of energy from a controlled fusion reaction. The first plasma is expected in 2025, while the first experiments using "burning" fusion fuel – a mixture of deuterium and tritium – are expected in 2032.
The above video – recently taken using a drone – shows that while construction is well under way, there is still some way to go.

We still might have to wait 30 years.

6. Hot topic: the future of fusion

Nuclear Engineering International

9 February 2017

http://www.neimagazine.com/features/featurehot-topic-the-future-of-fusion-5736033/

Ian Chapman, CEO of the UK Atomic Energy Authority, discusses the long running multi-million pound MAST Upgrade project and what he believes it will lead to in coming years.

Just imagine a source of energy that generates no carbon emissions and has millions of years of fuel. Sound too good to be true? Well maybe not; a worldwide research programme is making real progress into developing the process of nuclear fusion into a viable electricity source for the years after 2050.

The fusion, or sticking together, of deuterium and tritium nuclei (heavy isotopes of hydrogen) has long been known to release huge amounts of energy. It is inherently safe and produces short-lived radioactive waste compared with nuclear fission. However, fusion is very difficult – temperatures ten times hotter than the core of the Sun (a staggering 150-200 million degrees C) are needed in the gaseous fuel or 'plasma', before the nuclei fuse and release their energy.

Culham leading the world

The most promising route to harnessing the power of fusion is using strong magnetic fields to control and confine a ring-shaped plasma at these temperatures inside a machine known as a 'tokamak'. The UK Atomic Energy Authority (UKAEA) runs two tokamaks – JET and MAST – at its Culham site near Oxford. JET is Europe's tokamak and remains today – more than 30 years after its first experiments – the largest and most powerful fusion device in the world. Back in 1996, JET achieved the world record for fusion power produced, 16MW, some 70% of the power needed to heat the plasma.

JET continues to push the boundaries of fusion research today – currently preparing for experiments in 2019/20 which aim to use the optimal fusion fuels, deuterium and tritium, to sustain high fusion powers for much longer periods. JET experiments continue to be fundamental to the design and operation of its successor, Iter – a collaboration between Europe, Japan, China, US, South Korea, India and Russia, which is currently under construction at Cadarache in the South of France. Bigger and more powerful than JET, Iter will produce 500MW of fusion energy; approaching power plant scale.

By the mid to late 2030s, Iter will be informing the design of the first true fusion power station, DEMO, which it is expected will start up in around 2050.

In addition to JET, UKAEA also hosts the UK's own fusion experiment, MAST at Culham. With a more compact and efficient 'spherical tokamak' design, MAST is exploring the spherical tokamak as an innovative reactor design for a second or third generation fusion power plant. Presently coming to the end of a £45 million major upgrade, the new MAST Upgrade when it starts operation later this year, will specifically test technologies, notably plasma exhaust systems, for DEMO and the first commercial power stations.

Demanding engineering

Whilst creating artificial stars for energy may sound difficult, because of JET, MAST Upgrade and other tokamaks, the science is now relatively well understood. The largest challenges on the path to realising economically viable fusion power stations lie in advanced and very demanding engineering. Solving these engineering challenges will ultimately determine whether fusion is putting electricity on the grid in the years after 2050 or remains the domain of science fiction movies. Addressing these challenges head on are two brand new facilities at Culham – the Remote Applications in Challenging Environments (RACE) centre and the Materials Research Facility. RACE exploits UKAEA's expertise in robotic maintenance inside JET and is working with UK consortia to develop remote handling systems for Iter and Europe's proposal for DEMO. RACE has already enabled UK plc to win contracts worth well over £100 million. Meanwhile the Materials Research Facility specialises in materials testing at the nanoscale – key in developing specialist materials that can withstand the very high-energy neutrons produced by fusion reactions.

The future looks bright

Presently two-thirds of UKAEA's funding comes directly from Europe to operate JET, and whilst funding is secure till the end of 2018, Brexit makes planned operation up to 2020 and beyond more uncertain, but UKAEA is working closely with the UK government to make sure that the investment in JET up to now is not squandered. Sooner or later of course, JET will close, but the investment in MAST Upgrade and in Culham's robotics and materials facilities will ensure the UK remains a key player in the programme to develop commercial fusion. Indeed, UKAEA is determined to become a major design centre for the European DEMO device, ensuring that Europe remains world leading and UK industry capitalises from this multi-billion pound energy

technology of the future.
Furthermore, the benefits to nuclear extend beyond fusion. RACE's design expertise and testing facilities are supporting the much wider robotics and autonomous systems community, which includes the nuclear fission industry. Similarly, the Materials Research Facility's capabilities are deliberately synergistic with the testing of fission materials; vital in areas such as advanced reactor design activities and lifetime extension of existing nuclear plant.

These technology growth areas at Culham will ensure that the UK and Europe continue to be a pioneer in fusion research and also benefit more generally from the nuclear renaissance – vital for the low-carbon economy we all strive for.

7. Special Report: **Technology & Society**

Five technologies that will change how we live

Innovations range from gene editing to smart lightbulbs

FEBRUARY 16, 2017 by: **Madhumita Murgia**

https://www.ft.com/content/1bf4cdc8-f251-11e6-95ee-f14e55513608

1. Biotech

Since the early 2000s, the cost of sequencing a human genome — determining the precise order of nucleotides within DNA molecules that defines who we are — has dropped sharply. A genome that cost $100m to sequence in 2001 can today be sequenced for roughly $1,000.

This plummeting cost, along with the shortened timescales for sequencing DNA, has led to a revolution in biotechnology: gene hacking, or the ability to turn genes on and off, and to manipulate biology to our advantage. The most radical branch of this new technology is "gene editing" — a process by which our DNA code can be cut and pasted using molecular “scissors” for a variety of applications, including curing diseases such as cancers and HIV. Until recently, swapping the code was an arduous process. A new DNA cut-and-paste tool known as Crispr has made the process unexpectedly simple. Crispr has been used to create disease-resistant strains of wheat and rice, alter yeast to make biofuels and reverse blindness in animals. Ultimately, it could be used to edit defects out of human embryos.

2. Artificial intelligence

Artificial intelligence is not science fiction: it is already embedded in products we use every day. Apple’s Siri assistant, Amazon’s book recommendations, Facebook’s news feed and Spotify’s music discovery playlist are all examples of services driven by machine learning algorithms. This decades-old science is enjoying a renaissance today because of the deluge of data created by smartphones and sensors, and the supercomputing power that is available to crunch that data. According to technology research firm Tractica, the AI market will grow from $643.7m in 2016 to $36.8bn by 2025. Techniques such as deep learning and neural networks supposedly mimic the human brain: they spot broad patterns in enormous data sets in order to label images, recognise voices and make decisions. The next step is artificial general intelligence: an algorithm that will not have to be taught a specific skill such as a game of chess or a new language, but will acquire it through trial and error, just as a child does. Companies such as London-based DeepMind, owned by Google, and others are working to make this a reality.

3. Renewable energy

World leaders last year ratified the Paris Agreement on climate change. This aims to keep the global average temperature from rising more than 2C above pre-industrial levels and to attempt to keep the increase under 1.5C. Keeping this promise will require more renewable energy research over the next decade. In energy, researchers are trying to build a nuclear fusion reactor that would tap the same process that causes the sun to give off light and heat to create a source of clean energy. An intergovernmental partnership is building a $19bn fusion reactor, ITER, in France. Other innovations include artificial photosynthesis to make hydrocarbons in laboratories to power cars, and high-altitude wind power that involves kites and hot-air balloons acting as aerial wind turbines. Iceland is investing in geothermal technology, drilling for heat energy underground. Thirty years ago it started by using geothermal resources to heat towns and cities. Now, the entire country’s electricity and heating systems are powered almost fully by renewable energy, including geothermal and hydropower.

4. Connectivity

WiFi — a household staple that modern children take for granted — turned 25 last September. As more objects connect to the “internet of things” — an estimated 50bn of them by 2020, according to estimates from technology company Cisco — the future of WiFi lies in reducing the power it drains from internet-enabled devices. One innovation, invented by students at the University of Washington in Seattle, is known as “passive WiFi” which its inventors say consumes 10,000 times less power. It is currently slower than regular home broadband, but would work well for applications such as smart thermostats or lightbulbs. The WiFi community is also looking to develop higher-frequency bands that would be used over a limited range, such as in a house or car. Ultimately, WiFi itself could be replaced by a new superfast alternative called Li-Fi, which uses light to beam information through the air, instead of radio waves. Lightbulbs would act as routers for this technology. A pilot study earlier this year found that a Li-Fi prototype could send data 100 times faster than WiFi, allowing dozens of movies to be downloaded in minutes.

5. Smart appliances

Almost two-thirds of the human population is connected to the internet via smartphones, but these devices are not the only portal to the web. In 2016 there were 6.4bn connected things — excluding PCs, phones and tablets — in use worldwide, up 30 per cent from the previous year, according to technology analyst Gartner. The internet of things, as it is known, is this universe of objects — everything from cars to printers, lightbulbs to thermostats — that are no longer “dumb”, static things: they can learn your habits and be controlled remotely using an app.

The stereotypical smart appliance is the self-stocking refrigerator that replenishes your milk automatically. This innovation will replace a lot more than the sniff test. Cars are now computers, running more lines of code than the Apollo 11 spaceship on its way to the moon. As these computers become more intelligent, cars will drive themselves, potentially reducing traffic-related fatalities. Smart sensors can also transform industry, for instance by monitoring goods during transport, helping utility companies to measure energy usage and logistics companies to track vehicles over long distances.

8. Is Fusion

Energy in Our Future?

The U.S. is grossly underinvested in energy research, says Obama's science adviser. And that includes fusion power

https://www.scientificamerican.com/article/is-fusion-energy-in-our-future/

John Holdren has heard the old joke a million times: fusion energy is 30 years away—and always will be. Despite the broken promises, Holdren, who early in his career worked as a physicist on fusion power, believes passionately that fusion research has been worth the billions spent over the past few decades—and that the work should continue. In December, *Scientific American* talked with Holdren, outgoing director of the federal Office of Science and Technology Policy, to discuss the Obama administration's science legacy. An edited excerpt of his thoughts on the U.S.'s energy investments follows.

Scientific American: Have we been investing enough in research on energy technologies?

John Holdren: I think that we should be spending in the range of three to four times as much on energy research and development overall as we've been spending. Every major study of energy R&D in relation to the magnitude of the challenges, the size of the opportunities and the important possibilities that we're not pursuing for lack of money concludes that we should be spending much more.

But we have national labs that are devoted—

I'm counting what the national labs are doing in the federal government's effort. We just need to be doing more—and that's true right across the board. We need to be doing more on advanced biofuels. We need to be doing more on carbon capture and sequestration. We need to be doing more on advanced nuclear technologies. We need to be doing more on fusion, for heaven's sake.

Fusion? Really?

Fusion is not going to generate a kilowatt-hour before 2050, in my judgment, but—

Hasn't fusion been 30 years away for the past 30 years?

It's actually worse than that. I started working on fusion in 1966. I did my master's thesis at M.I.T. in plasma physics, and at that time people thought we'd have fusion by 1980. It was only 14 years away. By 1980 it was 20 years away. By 2000 it was 35 years away. But if you look at the pace of progress in fusion over most of that period, it's been faster than Moore's law in terms of the performance of the devices—and it would be nice to have a cleaner, safer, less proliferation-prone version of nuclear energy than fission.

My position is not that we know fusion will emerge as an attractive energy source by 2050 or 2075 but that it's worth putting some money on the bet because we don't have all that many essentially inexhaustible energy options. There are the renewables. There are efficient breeder reactors, which have many rather unattractive characteristics in terms of requiring what amounts to a plutonium economy—at least with current technology—and trafficking in large quantities of weapon-usable materials.

The other thing that's kind of an interesting side note is if we ever are going to go to the stars, the only propulsion that's going to get us there is fusion.

Are we talking warp drive?

No, I'm talking about going to the stars at some substantial fraction of the speed of light.

When will we know if fusion is going to work?

The reason we should stick with ITER [a fusion project based in France] is that it is the only current hope for producing a burning plasma, and until we can understand and master the physics of a burning plasma—a plasma that is generating enough fusion energy to sustain its temperature and density—we will not know whether fusion can ever be managed as a practical energy source, either for terrestrial power generation or for space propulsion. I'm fine with taking a hard look at fusion every five years and deciding whether it's still worth a candle, but for the time being I think it is.

To read more of the conversation with John Holdren—which includes his assessment of the future of U.S. science policy, the prospects for continued progress on brain science, and more—visit www.ScientificAmerican.com/john-holdren

This article was originally published with the title "Is Fusion in Our Future?"

9. Method for designing fusion experiments improved

Established method for shaping stellarator magnets receives critical update

14-Feb-2017

http://www.chemeurope.com/en/news/161862/method-for-designing-fusion-experiments-improved.html

Measure twice, cut once" is an old carpenter's proverb--a reminder that careful planning can save time and materials in the long run.

The concept also applies to the design of stellarators, which are complex nuclear fusion experiments meant to explore fusion's potential as an energy source. Stellarators work by confining a ring of blazing-hot plasma inside a precisely shaped magnetic field generated by external electromagnetic coils. When the plasma gets to several million degrees--as hot as the interior of the sun--atomic nuclei begin to fuse together, releasing massive amounts of energy.

Before turning a single bolt to build one of these rare and expensive devices, engineers create exacting plans using a series of algorithms. However, a wide variety of coil shapes can all generate the same magnetic field, adding levels of complexity to the design process. Until now, few researchers have studied how to choose the best among all potential coil shapes for a specific stellarator.

University of Maryland physicist Matt Landreman has made an important revision to one of the most common software tools used to design stellarators. The new method is better at balancing tradeoffs between the ideal magnetic field shape and potential coil shapes, resulting in designs with more space between the coils. This extra space allows better access for repairs and more places to install sensors.

> "Instead of optimizing only the magnetic field shape, this new method considers the complexity of the coil shapes simultaneously. So there is a bit of a tradeoff," said Landreman, an assistant research scientist at the UMD Institute for Research in Electronics and Applied Physics (IREAP) and sole author of the research paper. "It's a bit like buying a car. You might want the cheapest car, but you also want the safest car. Both features can be at odds with each other, so you have to find a way to meet in the middle."

Researchers used the previous method, called the Neumann Solver for

Fields Produced by External Coils (NESCOIL) and first described in 1987, to design many of the stellarators in operation today--including the Wendelstein 7-X (W7-X). The largest stellarator in existence, W7-X began operation in 2015 at the Max Planck Institute of Plasma Physics in Germany.

"Most designs, including W7-X, started with a specifically shaped magnetic field to confine the plasma well. Then the designers shaped the coils to create this magnetic field," Landreman explained. "But this method typically required a lot of trial-and-error with the coil design tools to avoid coils coming too close together, making them infeasible to build, or leaving too little space to access the plasma chamber for maintenance."

Landreman's new method, which he calls Regularized NESCOIL--or REGCOIL for short--gets around this by tackling the coil spacing issue of stellarator design in tandem with the shaping of the magnetic field itself. The result, Landreman said, is a fast, more robust process that yields better coil shapes on the first try.

Modeling tests performed by Landreman suggest that the designs produced by REGCOIL confine hot plasma in a desirable shape, while significantly increasing the minimum distances between coils.

"In mathematics, we'd call stellarator coil design an 'ill-posed problem,' meaning there are a lot of potential solutions. Finding the best solution is highly dependent on posing the problem in the right way," Landreman said. "REGCOIL does exactly that by simplifying coil shapes in a way that the problem can be solved very efficiently."

The development of nuclear fusion as a viable energy source remains far off into the future. But innovations such as Landreman's new method will help bring down the cost and time investments needed to build new stellarators for research and--eventually--practical, energy-generating applications.

"This field is still in the basic research stage, and every new design is totally unique," Landreman said. "With these incompatible features to balance, there will always be different points where you can decide to strike a compromise. The REGCOIL method allows engineers to examine and model many different points along this spectrum."

Original publication:

> *Matt Landreman; "An improved current potential method for fast computation of stellarator coil shapes"; Nuclear Fusion; 2017*

10. Positive future for nuclear, Amano tells summit

> 15 February 2017
> http://www.world-nuclear-news.org/NP-Positive-future-for-nuclear-Amano-tells-summit-1502175.html

future energy needs, International Atomic Energy Agency

(IAEA) director general Yukiya Amano told the World Government Summit in Dubai yesterday.

The event is a global platform dedicated to shaping the future of government worldwide. Each year, it sets the agenda for the next generation of governments with a focus on how they can harness innovation and technology to solve universal challenges facing humanity.

"The use of nuclear power looks set to continue to grow in the coming decades," Amano said during a plenary session on the future of nuclear power. He said many countries were considering nuclear power in order to address development and energy security, and to help mitigate climate change.

Thirty countries are considering introducing nuclear energy, he said, and need support in order to use it safely, securely and sustainably.

Amano highlighted the importance of nuclear safety and security. He stressed that lessons have been learned from the 2011 accident at Japan's Fukushima Daiichi plant. "After Fukushima, no one challenges that safety must come first," he said. "And we have learned many lessons from this accident. I see the changes in every nuclear power plant I visit."

During the summit, Amano met with Sheikh Abdullah bin Zayed Al Nahyan, United Arab Emirates' minister of foreign affairs and international cooperation. They discussed ways to enhance cooperation between the UAE and the Vienna-based agency.

Speaking to Mohamed Al Hammadi, CEO of Emirates Nuclear Energy Corporation, Amano said, "We will continue to work closely with the UAE as they complete all four units at Barakah, and throughout the operating life of the facility and beyond." He added, "I very much welcome that the UAE is now sharing their experience with other newcomers to nuclear power."

Researched and written
by World Nuclear News

11. Waste shipments to WIPP expected to resume soon

16 February 2017

http://www.world-nuclear-news.org/WR-Waste-shipments-to-WIPP-expected-to-resume-soon-1602174.html

> **The shipment of transuranic wastes from generator sites to the Waste Isolation Pilot Plant (WIPP) in New Mexico is set to resume in April. The US Department of Energy (DoE) expects a total of 128 shipments to be made to WIPP over the next 12 months.**

WIPP began operations in 1999 and is the USA's only repository for the disposal of transuranic (TRU) wastes from its military program. The wastes - clothing, tools, rags, residues, debris, soil and other

items contaminated with small amounts of plutonium and other man-made radioactive elements - are sealed in drums and disposed of underground in rooms mined out of an ancient salt formation.
Operations at the WIPP underground storage facility were suspended in February 2014 following two unrelated incidents. First, operations were stopped following a fire in an underground vehicle on 5 February. Nine days later, a radiological event occurred underground when a waste drum ruptured following an exothermic chemical reaction in organic absorbent material used in the drum to stabilise liquids and nitrate salts.
The DoE eventually authorized operator Nuclear Waste Partnership to resume waste emplacement in late December 2016, confirming that all pre-start corrective actions identified in two operational readiness reviews and other required actions had been completed.
The first waste emplacement operations were completed on 4 January, with waste from the DoE's Savannah River site which had been in storage at WIPP's Waste Handling Building (WHB).
All the facilities that generate TRU waste normally sent to WIPP have in the meantime been storing their wastes on-site while the facility has been out of action. DoE earlier said all recertified waste from the WHB is to be emplaced before WIPP begins accepting new waste shipments.
DoE has now announced shipments from generator sites are expected to resume in April.
"Shipments from a given site can commence once the site has demonstrated its readiness to load and ship TRU containers and has verified that waste destined for WIPP meets the updated Documented Safety Analysis requirements," DoE said. "The exact allocation and sequence for shipping will be adjusted based on the emplacement rate at WIPP, operational needs at WIPP and generator sites, and logistical issues (such as weather) that affect shipping."
DoE has released preliminary estimates for the resumption of shipments of TRU waste to WIPP over the next 12 months. By the end of January 2018, DoE estimates WIPP to receive 61 shipments from Idaho; 24 from Oak Ridge; 24 from Los Alamos; eight from Savannah River site and 11 from Waste Control Specialists.
Carlsbad Field Office manager Todd Shrader said, "We are pleased that WIPP is once again emplacing waste. The suspension of disposal operations has posed challenges at DoE sites, with backlogs of TRU waste building up. Resuming shipments from generator sites is important to support cleanup and ongoing missions at those sites. We look forward to doing that as soon and as safely as possible."

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by World Nuclear News

12. NuGen welcomes PM 'commitment' to Moorside

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http://www.world-nuclear-news.org/NP-NuGen-welcomes-PM-commitment-to-Moorside-16021701.html

NuGeneration has welcomed the British prime minister's comments yesterday about the importance of building a new nuclear power plant in West Cumbria, while the Institution of Mechanical Engineers has said the UK's plan to leave the European Atomic Energy Community (Euratom) as part of Brexit could threaten new nuclear reactor projects.

NuGen, which is the UK joint venture between Japan's Toshiba Corp and France's Engie, said on 14 February that Toshiba is committed to Moorside despite announcing it would reduce its exposure to reactor construction projects outside Japan. NuGen plans to build a nuclear power plant of up to 3.8 GWe gross capacity at the site in West Cumbria, using AP1000 nuclear reactor technology provided by Westinghouse.

NuGen CEO, Tom Samson, said: "The comments by the prime minister further demonstrate the UK's commitment to nuclear new build and recognise the importance of the Moorside project and the vital role nuclear, and NuGen, have to play. NuGen remains committed to developing and delivering the next generation of nuclear power in the UK. The strong support of the UK government strengthens our investment case for safe, reliable, affordable, low-carbon energy using proven technology. NuGen has been working with the government to ensure Moorside will feature as a vital part of the UK’s future energy mix and we will continue to collaborate with the government as we address the challenges and move the project forward."

Prime Minister Theresa May was questioned about Moorside during her visit yesterday to Bootle, ahead of the Copeland by-election taking place next week.

May, whose comments were broadcast on national television, said: "The consortium involved in Moorside has been absolutely clear. They have reconfirmed their commitment to Moorside. The Business Secretary Greg Clark has spoken to NuGen and Toshiba in the last few days and, in fact, over the last six months, he has made three visits to Japan, working with the government there and businesses there about their investment here in the UK."

The by-election in the seat of Copeland, in which the Sellafield site is located, was triggered by the resignation in December of Jamie Reed as a member of parliament for the UK's Labour Party. Reed resigned to become head of development and community relations at Sellafield Ltd. In January, May's Conservative Party announced its candidate for the Copeland seat - Trudy Harrison, who worked as

a technical clerk for Sellafield Ltd for five years until 1998 and whose husband Keith is a welder working in the nuclear industry.
Labour has chosen Gill Troughton, a councillor and former doctor and ambulance driver, as its candidate.
May said: "We recognise - and Trudy Harrison, our candidate here in Copeland, has made very clear to me - the importance of Moorside and the importance of the nuclear industry."

Planning for Euratom exit

The government's plan to leave the European Union, and consequently Euratom could threaten plans to build new nuclear reactors and decommissioning activities, the Institution of Mechanical Engineers says in a report it published today. The plan could also jeopardise energy security due to the impact on nuclear fuel supplies, said the London-based organisation, which has more than 115,000 members in over 140 countries.
The report, entitled *Leaving the EU: the Euratom Treaty*, says the government must "urgently develop a suitable transitional framework" before leaving the EU. There is the need, it says, for the UK to create new nuclear cooperation agreements (NCAs) to enable new nuclear trade deals with both EU and non-EU countries.
Jenifer Baxter, head of energy and environment at the institution and lead author of the report, said: "The UK's departure from Euratom must not be seen as an after-thought to leaving the EU. Without suitable transitional arrangements, the UK runs the risk of not being able to access the markets and skills that enable the construction of new nuclear power plants and existing power stations may also potentially be unable to access fuel.
"With the Article 50 process taking just two years, the UK government must act quickly to start the process to develop NCAs to enable international trade, for goods such as nuclear fuels and research. [The] government must also make sure that the UK will be able to access sector specific skills not currently available in the UK, such as centrifuge technology expertise. There needs to be a thorough framework in place to provide assurances on nuclear safety, nuclear proliferation and environmental issues.
"Making these transitional arrangements will be difficult, particularly given the short time-scale, but if done correctly could present the UK with opportunities to speed up the process of developing new nuclear power plants and reprocessing facilities, boost UK nuclear skills as well as open up the UK to more international trade deals."
The report makes three recommendations.
The government must develop a suitable transitional framework that provides the UK nuclear industry an alternative State System of Accountancy and Control creating the same provision as Euratom prior to leaving the EU and Euratom treaties, it said.
"The Institution would welcome the opportunity to support the UK

Government and the Office for Nuclear Regulation in the development of this system," it added.
The government must create new NCAs with Euratom and non-EU trading countries prior to leaving Euratom, it said.
"Specific commitments for nuclear goods, services and research activities should be made as part of new trade deals with the USA, Canada, Australia, China and South Africa. The Institution would welcome the opportunity to support the Departments for Business, Energy and Industrial Strategy and International Trade in developing these commitments."
Its third recommendation is that the government, through the National Decommissioning Authority, "enables innovative commercial opportunities to sell nuclear services and waste treatment technology to world trade partners".
Explanatory notes to a bill authorising Brexit the government published on 26 January state the document empowers the prime minister to leave both the European Union and Euratom. The peaceful use of nuclear energy within the EU is governed by the 1957 Euratom Treaty.
The Euratom Community is a separate legal entity from the EU, but it is governed by the bloc's institutions. Euratom is thus enforceable by the European Court of Justice.
Secretary of State for Exiting the European Union David Davis told the House of Commons on 31 January the 2008 EU Amendment Act "makes clear" that in UK law membership of the European Union includes Euratom. Article 50 of the Lisbon Treaty, he added, thus applies both to the EU and Euratom.
May has said she plans to trigger Article 50 and thus start the Brexit process next month.
Researched and written
by World Nuclear News

13. Poroshenko: Ukraine increasing nuclear share to 60%

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http://www.world-nuclear-news.org/NP-Poroshenko-Ukraine-to-increase-nuclear-share-to-60-17021701.html

Nuclear energy's share of Ukraine's electricity mix is "rapidly approaching" 60%, President Petro Poroshenko said at a meeting of the country's National Security and Defence Council yesterday, according to a statement on the presidential website. The president did not give a date by which the increase would be achieved.
Ukraine has 15 nuclear units in commercial operation at four sites - Khmelnitsky, Rovno, South Ukraine and Zaporozhe - which are all operated by state-owned Energoatom. The units comprise 13 VVER-

1000s and two VVER-440s with a total capacity of 13,835 MWe. Ukraine receives most of its nuclear services and nuclear fuel from Russia, but is reducing this dependence by buying fuel from Westinghouse, the US-headquartered subsidiary of Japan's Toshiba.
"I am pleased to inform [you] that we have increased the share of nuclear energy in the overall energy balance. From 47% we are rapidly approaching 60%. This is [equivalent to] millions of tons of coal that Ukraine no longer needs," Poroshenko said.
A large share of primary energy supply in Ukraine comes from the country's uranium and substantial coal resources. The remainder is oil and gas, mostly imported from Russia. Total electricity production in 2014 amounted to 183 TWh, with 8 TWh net exports to Europe. In 2014, 88 TWh was from nuclear, 71 TWh from coal, 13 TWh from gas, and 9 TWh from hydro. Electricity consumption was 134 TWh after transmission losses of 20 TWh due to old grid. Peak demand is about 28 GWe. Total capacity is about 52 GWe, including 22 GWe coal-fired, 13.8 GWe nuclear, 5 GWe gas and 4.8 GWe hydro. Much of the coal-fired plant is old and with unconstrained emissions, and nearly half of it is due to close down. In 2014, 48.6% of electricity was from nuclear, and in 2015, 82.4 TWh comprised 56.5%.
Poroshenko also said he welcomed plans to upgrade the generating capacities of power plants fired by anthracite coal, which is made almost entirely of carbon.
Work to significantly increase the efficiency and improve the operation of all types of power plants in the country "must be started immediately" as it will take two to three years, he said.
The president also mentioned cooperation with Poland and China in the "modernisation" of Ukrainian energy companies. "I have discussed attracting financing with my Polish colleagues and the opportunity of using Chinese loans with President of China Xi Jinping," he said.
In March 2015, Energoatom, Ukrenergo and Polenergia signed a memorandum of understanding on a project to export electricity via European grids.
Ukrenergo is a Ukrainian state-run power distribution company, while Polenergia is a vertically integrated group of companies working in energy generation, trading and distribution. Polenergia is part of Kulczyk Investments, a privately-owned Polish investment company.
Energoatom said then the agreement would make it possible to use all its available nuclear capacity and attract funds for the completion of the third and fourth reactors of its Khmelnitsky nuclear power plant. In July the same year, the Ukrainian government approved a pilot project, named the "energy bridge", to transfer electricity from unit 2 of the Khmelnitsky plant to the European Union.
In November last year, Energoatom agreed to enhance its

cooperation with Chinese, Argentinian and Spanish companies - respectively, China National Nuclear Power, Nucleoeléctrica Argentina SA and IDOM Nuclear Services.

Researched and written
by World Nuclear News

14. EU, IAEA agree to bolster cooperation

17 February 2017

http://www.world-nuclear-news.org/NP-EU-and-IAEA-agree-to-bolster-cooperation-1702174.html

The European Union and the International Atomic Energy Agency (IAEA) agreed to strengthen their cooperation in a range of nuclear activities, including nuclear science applications, during a meeting in Brussels this week.

The fifth annual senior officials meeting was held at the headquarters of the European Commission (EC) on 15 February. The meeting was co-chaired by Cornel Feruta, IAEA chief coordinator and Marco Giacomini, EC deputy managing director for human rights, global and multilateral issues.

The meeting provided a forum to exchange views on enhancing collaboration in nuclear safety, security, safeguards, sustainable development, nuclear energy research and innovation, and nuclear science applications. Discussions were also held on mechanisms to strengthen regional cooperation, including for the environmental remediation of uranium legacy sites in Central Asia.

In a joint statement, the EC and IAEA said nuclear safety "is a key priority that will remain at the centre of cooperation" between them.

The EC said issues such as decommissioning and radioactive waste management "should receive additional attention, and benefit from increased stakeholder involvement with a focus on increasing transparency on funding and processes leading to national and/or shared repositories".

Talks also focused on EU support for IAEA activities in the areas of nuclear security, strengthening the security of nuclear and radioactive materials, and building on the results of the 2016 International Conference on Nuclear Security. Progress on construction of the IAEA's low-enriched uranium fuel 'bank' in Oskemen, Kazakhstan, including continued support from the EU, was also discussed.

On the side lines of the meeting, practical arrangements on cooperation in the field of nuclear science and applications for sustainable development were signed by IAEA deputy director general Aldo Malavasi and Vladimir Sucha, director general of the European Commission's Joint Research Centre.

Giacomini said, "The EU continues to attach great importance to the IAEA's core responsibilities in the field of non-proliferation, nuclear energy, nuclear safety, nuclear security and technical cooperation." He added, "The strong political support by the Union and its member states is backed also financially and technically."
Feruta said the meeting was a good opportunity to review progress in cooperation between the EU and the IAEA and to discuss next steps in priority areas. He said these included providing support to EU member states in implementing the United Nations' Sustainable Development Goals.
Researched and written
by World Nuclear News

15. US consortium calls for public-private SMR support

20 February 2017
http://www.world-nuclear-news.org/NN-US-consortium-calls-for-public-private-SMR-support-2002177.html

A consortium of small modular reactor (SMR) developers and customers has issued a policy statement setting out the benefits of public-private partnerships to facilitate the commercialisation and export of US-designed SMRs.
The SMR Start consortium, which was launched in January 2016, said SMRs were a "strategic option" for the US to meet the need for new generation capacity from the mid-2020s onwards.
Commercialisation of new nuclear technologies involves large upfront first-of-a-kind costs and a relatively long timeframe to complete licensing and design activities, the consortium said. Investment of such amounts, over the timeframes required and without contractual commitments, presented a "unique challenge" to companies, the consortium said.
Public-private partnerships - similar to those that provide support for the introduction of other new energy technologies - would help ensure the successful commercialisation of SMRs, the consortium said, stimulating the private investments required to ensure that the technology continues to advance and is capable of competing in overseas markets without additional direct support once the technology matures. "Such partnerships are an appropriate policy due to the public benefits derived from SMRs that are not valued in the energy markets, such as carbon-free generation and improved electricity grid reliability", it said.
The policy document called on the US government to establish public-private partnerships to support the development of two or more SMR designs, the deployment of four or more commercial SMR facilities domestically, and the development of a domestic supply chain to support the SMR market, including the export of

SMRs.
It said the US Department of Energy's (DoE's) SMR Licensing Technical Support (LTS) program, providing initial funding of up to $452 million on a cost share basis, was "much appreciated but not sufficient in the current business environment to achieve large-scale SMR commercialisation." It called for the LTS program, scheduled to end in fiscal 2017, to be expanded to cover design finalisation as well as licensing and to be extended to fiscal 2025, "with a commensurate increase in funding".
Public-private partnerships could support the deployment of SMRs through a combination of production tax credits, power purchase agreements and loan guarantees, the consortium said. Technology development could be supported through grid security and reliability programs and accelerated through access to and support from national laboratories.
Investment tax credits (ITC) could support investments in SMR design and construction, and "kick-start" a supply chain and the manufacturing of components for both domestic and international SMR markets. "One SMR designer has invested in excess of $300 million in a state-of-the-art purpose-built SMR manufacturing facility in the US", it noted. "An SMR ITC should be established to incentivise investments in US SMR manufacturing facilities. This is similar in amount to the ITC for renewable energy sources", it said.
"Private companies and DoE have invested over $1 billion in the development of SMRs. However, more investment, through public-private partnerships is needed in order to assure that SMRs are a viable option in the mid-2020s. In addition to accomplishing the public benefit from SMR deployment, the federal government would receive a return on investment through taxes associated with investment, job creation and economic output over the lifetime of the SMR facilities that would otherwise not exist without the US government's investment," the consortium said.
SMRs can generally be described as nuclear reactors with a typical capacity of 300 MWe equivalent or less, designed with modular technology using module factory fabrication, allowing economies of series production and short construction times. The DoE has supported their development through several initiatives.
Earlier this year NuScale Power submitted the first-ever SMR design certification application to the US Nuclear Regulatory Commission, with a preferred site identified at the Idaho National Laboratory for a potential first-of-a-kind reactor. The regulator has also accepted for review from the Tennessee Valley Authority an application for an early site permit for a potential SMR at Clinch River in Tennessee. The application was developed with the support of the DoE's LTS program.

SMR Start was established by SMR vendors and potential customers to advocate for SMRs in the USA. Its members are Areva, Bechtel, BWXT, Dominion, Duke Energy, Energy Northwest, Fluor, Holtec International, NuScale Power, Ontario Power Generation, PSEG Nuclear, Southern Nuclear, the Tennessee Valley Authority and Utah Associated Municipal Power Systems. The US Nuclear Energy Institute collaborates with the consortium on policies and priorities relating to SMR technology.

Researched and written
by World Nuclear News

16. Europe to Lead Research Project for Energy Storage in Molten Silicon

February 20, 2017

By Renewable Energy World Editors

http://www.renewableenergyworld.com/articles/2017/02/europe-to-lead-research-project-for-energy-storage-in-molten-silicon.html

The Technical University of Madrid (UPM) last week said that it will work with seven European R&D institutions to develop a new generation of ultra-compact energy storage devices based in molten silicon and solid state heat-to-power converters.

The Horizon-2020 Research Project AMADEUS will work on the storage of energy at temperatures higher than 1000 degrees Celsius using molten silicon-based alloys.

UPM said that the direct storage of solar energy in thermal solar power plants, or the integration of both electric power storage and cogeneration in the housing sector and urban areas, are examples of the potential applications of the devices to be developed by the project.

With a budget of 3.3 million euros (US$3.2 million) for the next three years, AMADEUS (Next Generation Materials and Solid State Devices for Ultra High Temperature

Energy Storage and Conversion) will search for new materials and devices allowing the energy storage at temperatures between 1000 and 2000 degrees Celsius, breaking the 600-degrees-Celsius mark, rarely exceeded by current concentrated solar power (CSP) systems.

The research consortium, coordinated by Alejandro Datas and Antonio Martí, of UPM, will receive support from the National Research Council (Italy), Foundry Research Institute (Poland), Norwegian University of Science and Technology (Norway), The Centre for Research & Technology, Hellas (Greece), University of Stuttgart (Germany) and IONVAC Process SRL (Italy).