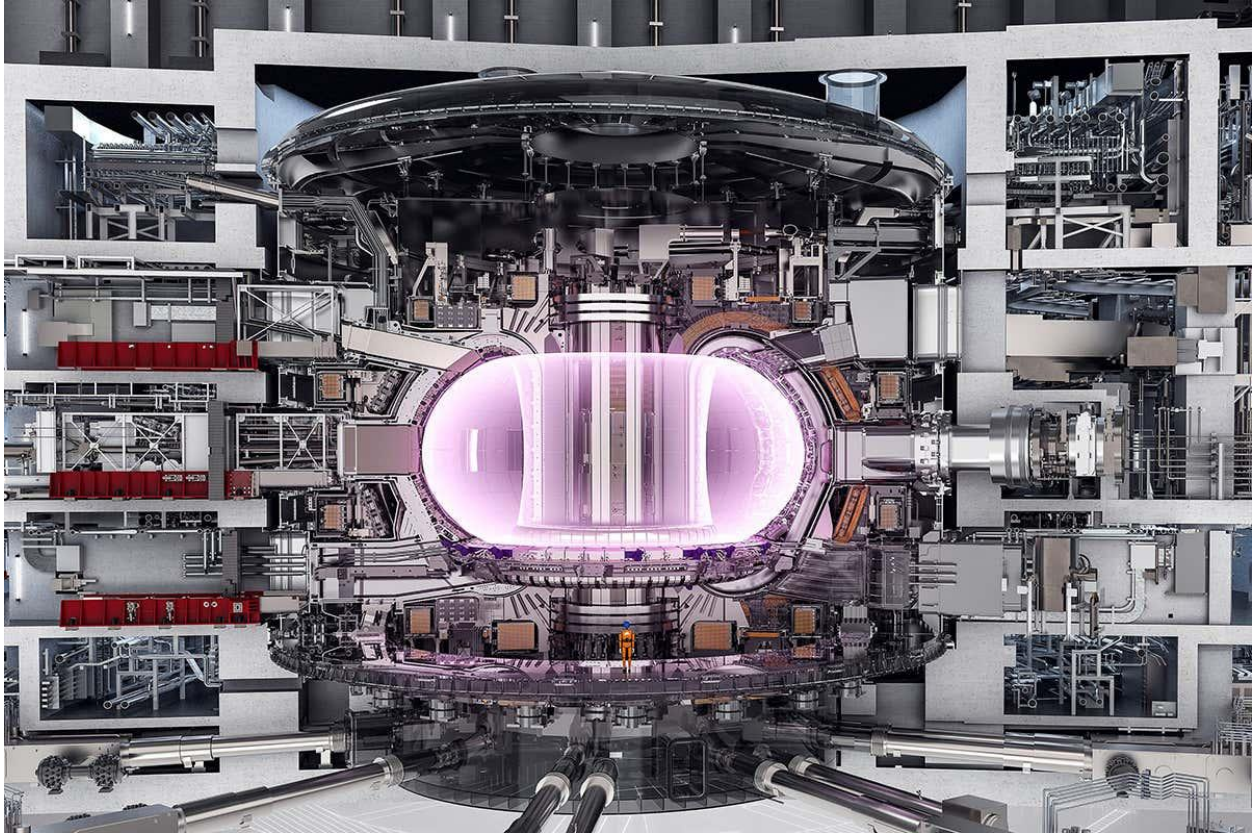


CLEAN ENERGY VOL 2



‘World’s first’ grid-scale nuclear fusion power plant announced in the US

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Commonwealth Fusion Systems's tokamak, a donut-shaped machine used to create nuclear fusion, in Devens, Massachusetts, October 11, 2023.

If all goes to plan, Virginia will be the site of the world’s first grid-scale [nuclear fusion power plant](#), able to harness this futuristic clean power and generate electricity from it by the early 2030s, according to an announcement Tuesday by the startup Commonwealth Fusion Systems.

CFS, one of the largest and most-hyped nuclear fusion companies, will make a multibillion-dollar investment into building the facility near Richmond. When operational, the plant will be able to plug into the grid and produce 400 megawatts, enough to power around 150,000 homes, said its CEO Bob Mumgaard.

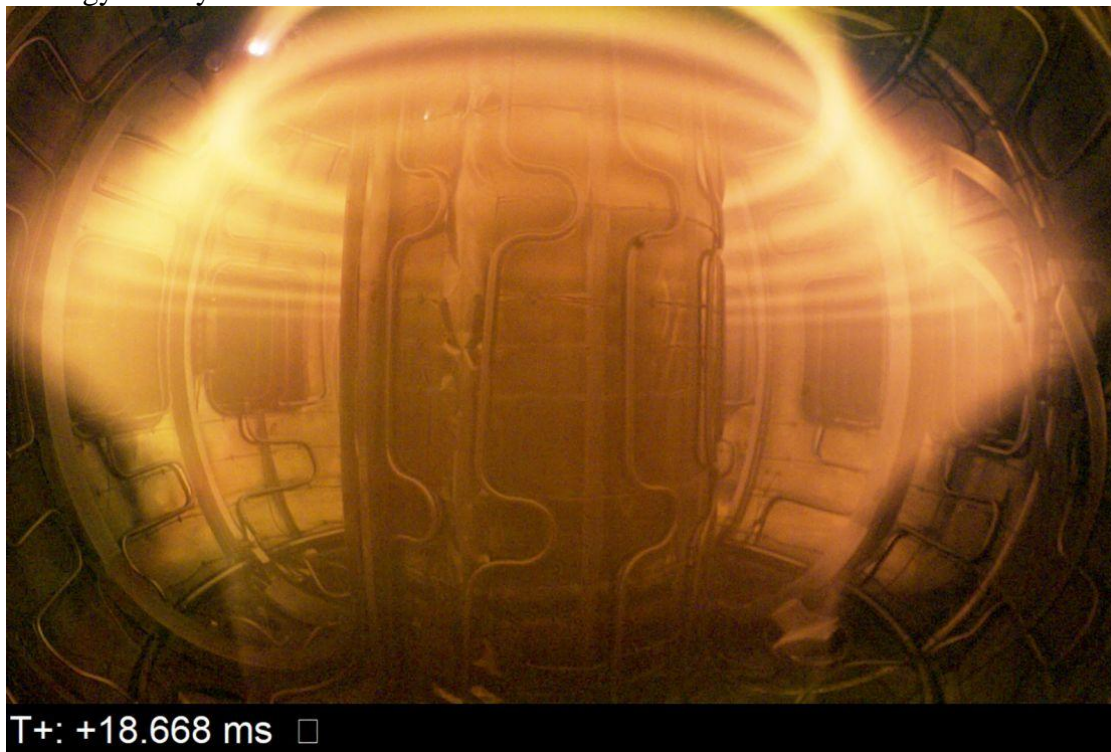
“This will mark the first time fusion power will be made available in the world at grid scale,” Mumgaard said. Virginia Gov. Glenn Youngkin welcomed the announcement, calling it “an historic moment for Virginia and the world at large.”

The plant would represent a new stage in the quest to commercialize nuclear fusion, the process which powers the stars. But the path toward it is unlikely to be smooth, not least because the technology has not yet been proved viable. The world is desperate for a clean, abundant source of energy that can replace fossil fuels as an always-available baseload power: nuclear fusion [promises to be just that](#).

It involves fusing atoms together to create a powerful burst of energy, achieved using the most abundant element in the universe: hydrogen. The most popular technology uses a donut-shaped machine called a tokamak. Fusion is near limitless, produces no planet-heating pollution and unlike fission, the nuclear technology the world currently uses, it leaves no legacy of long-term nuclear waste.

But taking it from research projects in labs around the world to commercial use has proved fiendishly difficult. A common joke in the industry is that, for decades, fusion has been just decades away. It’s something CFS acknowledges. “Nothing occurs overnight in fusion,” Mumgaard said. But the startup, which was spun out of MIT in 2018 and has raised more than \$2 billion so far, says it is moving at pace.

It is “deep into” building a tokamak able to demonstrate net fusion energy: meaning a reaction that produces more energy than it consumes. It hopes to produce its first plasma – the superheated cloud of charged gas in which fusion reactions happen – in 2026 and achieve net fusion energy shortly afterward.



Plasma confined in a tokamak designed by Energy singularity, a Chinese nuclear fusion startup, during an experiment. Energy Singularity

Building, owning and operating a power plant to plug fusion power into the grid is its “next act,” Mumgaard said.

The startup looked at more than 100 locations around the world for the power plant before choosing the James River Industrial Center in Virginia. The site is owned by Dominion Energy, which will lease it to CFS and provide technical assistance. The construction process is set to be long and CFS says it is still seeking permits.

The location was chosen for its growing economy, skilled workforce, clean energy focus and the ability it offered to connect into the grid after the retirement of a coal plant, CFS said.

“In the early 2030s, all eyes will be on the Richmond region ... as the birthplace of commercial fusion energy,” Mumgaard said.

Virginia is also the [world’s largest](#) data center market, a sector that requires [huge and growing amounts](#) of energy. Data center electricity consumption in the US is expected to triple by 2030, equivalent to the amount needed to power around 40 million US homes, according to a Boston Consulting Group [analysis](#).

CFS says the Virginia plant is intended to be the first of thousands they plan to put onto the grid in the future.

The startup is [far from the only private company](#) trying to accelerate the timeline toward achieving and commercializing nuclear fusion, with others also promising to do so by early next decade.

In general, nuclear fusion startups “tend to be a little aggressive in what they’re promising,” Jerry Navratil, a professor of fusion energy and plasma physics at Columbia University, told CNN last month. There’s a big difference between producing energy from fusion and having a practical system that puts power on the grid and is safe, licensed and operating, he added.

Mumgaard acknowledged “there will be bumps in the road and things won’t change overnight.” But, he added, “the designers and planners can now go from a general notion to a specific location for the next chapter in the fusion journey.”



Governor of Virginia

Glenn Youngkin

Strengthen the Spirit of Virginia

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Governor Glenn Youngkin Announces World's First Commercial Fusion Power Plant

*Commonwealth Fusion Systems will invest several billion dollars and create hundreds of jobs in
Chesterfield County*

RICHMOND, VA — Governor Glenn Youngkin today announced that Commonwealth Fusion Systems, the largest private fusion company, will make a multi-billion dollar investment to build the world's first grid-scale commercial fusion power plant at the James River Industrial Center in Chesterfield County, Virginia, on a site owned by Dominion Energy. The project will create hundreds of temporary and permanent jobs in the region.

“This is an historic moment for Virginia and the world at large,” said **Governor Glenn Youngkin**. “Commonwealth Fusion Systems is not just building a facility, they are pioneering

groundbreaking innovation to generate clean, reliable, safe power, and it's happening right here in Virginia. We are proud to be home to this pursuit to change the future of energy and power.”

“Virginia offers a strong talent pool and the Chesterfield County site is excellent for fusion energy’s debut,” **said Secretary of Commerce and Trade Caren Merrick.** “Commonwealth Fusion Systems will create hundreds of temporary construction jobs then full-time jobs once operations begin.”

Headquartered in Massachusetts, CFS conducted a global search for the site of its first commercial fusion power plant, known as ARC, which the company will independently finance, build, own, and operate. ARC will generate about 400 megawatts of electricity — enough energy to power large industrial sites or about 150,000 homes. The project is expected to spur billions of dollars in economic development in the region and create hundreds of jobs during the long-term operation of the power plant.

“In the early 2030s, all eyes will be on the Richmond region, and more specifically Chesterfield County, as the birthplace of commercial fusion energy,” **said CFS Co-founder and Chief Executive Officer Bob Mumgaard.** “Virginia emerged as a strong partner as they look to implement innovative solutions for both reliable electricity and clean forms of power. We are pleased to collaborate with Dominion Energy.”

“Commonwealth Fusion Systems is the clear industry leader in advancing the exciting energy potential of fusion,” **said Dominion Energy Virginia President Edward H. Baine.** “Our customers’ growing needs for reliable, carbon-free power benefits from as diverse a menu of power generation options as possible, and in that spirit, we are delighted to assist CFS in their efforts.”

“There could not be a more significant project for the first grant of Virginia's Clean Energy Innovation Bank than the world's first commercial fusion plant,” **said Virginia Department of Energy Director Glenn Davis.** “Virginia Energy is excited about what this project could mean to the Commonwealth, our nation, and the world.”

“This is a tremendous announcement for Chesterfield County, the Commonwealth of Virginia, and the future of clean energy generation across the globe,” **said Senator Mark Warner.** “As we continue to build a clean energy economy, fusion energy is poised to play a critical role in providing the firm, reliable, and clean power needed to support growing energy demands in Virginia and across the nation. I’m incredibly proud Virginia will host this first-of-a-kind commercial fusion power plant and look forward to the continued development of this transformational technology.”

“I’m thrilled Commonwealth Fusion Systems is investing billions to build a fusion power plant in Chesterfield County, which will create hundreds of jobs. The large-scale commercialization of this technology, which I saw when I visited a lab at Massachusetts Institute of Technology a decade ago, was made possible by federal funding,” **said Senator Tim Kaine.** “I’m proud of the federal legislation I’ve helped pass that enables Virginia to accelerate its leadership in clean

energy, especially the *Inflation Reduction Act* that provides strong tax incentives for CFS locating on the Chesterfield site.”

“I am thrilled to see a powerful step in fusion development undertaken in my beloved Virginia,” **said Congressman Don Beyer**. “Bringing clean, safe fusion energy to the grid is a longstanding dream that could dramatically boost standards of living in America and around the world, and I am so proud that our Commonwealth will help lead the way towards realizing that dream. As the founder of the bipartisan Fusion Energy Caucus, I look forward to continued efforts to support and grow American leadership on fusion in years to come.”

“As we continue the transition away from fossil fuels to cleaner, more sustainable energy sources, we must leverage every available technology,” **said Congresswoman Jennifer McClellan**. “Commonwealth Fusion System’s innovative energy source will help reduce our reliance on fossil fuels and aid in our continued fight against the climate crisis. I look forward to the launch of the ARC fusion power plant here in Virginia’s Fourth. This groundbreaking investment will create new jobs, stimulate our local economy, and position our congressional district as a trailblazing leader in clean-energy technologies.”

“Today’s announcement is a transformative step toward realizing an affordable, clean energy future for Virginia’s First District, the Commonwealth, and the nation,” **said Congressman Rob Wittman**. “This project in Chesterfield County will provide safe, clean, and reliable power for consumers and companies looking to do business in the Richmond area while bringing hundreds of jobs that will benefit Virginia’s First District residents. I’m thrilled that this commercial fusion power plant will help our region remain attractive for economic growth, and I thank Commonwealth Fusion Systems, Dominion Energy, and all of our state and local government partners for making this happen.”

“I am delighted that a clean energy innovator such as Commonwealth Fusion Systems has selected Chesterfield County for this groundbreaking plant,” **said Senator Ghazala Hashmi**. “This announcement is a major milestone in Virginia’s energy history.”

“The future of clean energy is being built right here in Virginia. Commonwealth Fusion Systems’ decision to invest in Chesterfield County is a game-changer—not just for our economy, but for the world’s energy future,” **said Speaker Don Scott**. “This historic project will create hundreds of jobs, power thousands of homes, and position Virginia as a global leader in innovation and clean energy technology. I’m proud to see the Commonwealth at the forefront of this transformative moment.”

“Virginia-made energy is the future! The first-ever commercial fusion power plant is an exciting opportunity for Chesterfield and for the Commonwealth,” **said Senator Glen Sturtevant**. “The opportunity to harness American and Virginia-made clean, safe energy is an important step to power Virginia’s electricity needs.”

“This innovative power plant represents both a major step forward for clean energy generation and good jobs for residents of Chesterfield County and the Richmond area,” **said Delegate Delores McQuinn.** “I am excited to see the results of this groundbreaking investment.”

“What used to be science fiction is about to become a reality in Chesterfield--and thus in the whole world,” **said Delegate Lee Ware.** “Once made commercially viable, power generated by nuclear fusion will become indispensable to the ‘All-of-the-Above’ resources needed to provide reliable and affordable electricity for Virginians.”

“The Board of Supervisors is grateful this innovative company has chosen Chesterfield for its new fusion facility,” **said Chesterfield County Board of Supervisors Chairman James Holland.** “Chesterfield is the home of many firsts, and we welcome the opportunity to be a part of Commonwealth Fusion Systems’ pursuit to be the world’s first grid-scale commercial fusion power plant. The county’s prime location, educated workforce, and competitive tax structure make us the perfect choice for this pioneering business.”

CFS is currently completing development of its fusion demonstration machine, SPARC, at its headquarters in Devens, Massachusetts. SPARC is expected to produce its first plasma in 2026 and net fusion energy shortly afterward, demonstrating for the first time a commercially relevant design that will produce more power than consumed. SPARC paves the way for ARC, which is expected to deliver power to the grid in the early 2030s.

CFS was spun out of Massachusetts Institute of Technology in 2018. Since then, it has raised more than \$2 billion in capital. In addition to this private capital, CFS has been awarded \$16.5 million in grants from the U.S. Department of Energy. The most recent grant of \$15 million was announced in June 2024 as part of the first phase of the DOE’s Milestone-Based Fusion Development Program.

The Virginia Department of Energy partnered with Virginia Economic Development Partnership, Chesterfield County, and Dominion Energy to secure this project. This project includes a \$1 million grant by the Virginia Clean Energy Innovation Bank matched with a \$1 million grant by Chesterfield County.

Plasma heating efficiency in fusion devices boosted by metal screens



An artist's representation of a metal screen filtering electromagnetic heating waves. Credit: Kyle Palmer / PPPL Communications Department

Heating plasma to the ultra-high temperatures needed for fusion reactions requires more than turning the dial on a thermostat. Scientists consider multiple methods, one of which involves injecting electromagnetic waves into the plasma, the same process that heats food in microwave ovens. But when they produce one type of heating wave, they can sometimes simultaneously create another type of wave that does not heat the plasma, in effect wasting energy.

In response to the problem, scientists at the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) have performed computer simulations confirming a technique that prevents the production of the unhelpful waves, known as slow modes, boosting the heat put into the plasma and increasing the efficiency of the fusion reactions.

"This is the first time scientists have used 2D computer simulations to explore how to reduce slow modes," said Eun-Hwa Kim, a PPPL principal research physicist and lead author of the [paper](#) reporting the results in *Physics of Plasmas*.

"The results could lead to more efficient plasma heating and possibly an easier path to fusion energy."

The team, which included researchers from General Atomics who use the DIII-D tokamak fusion facility, determined that positioning a metal grate known as a Faraday screen at a slight five-degree slant with respect to the antenna producing the heating waves, also known as helicon waves, stops the production of the slow modes. Researchers want to avoid creating slow modes, because unlike helicon waves, they cannot penetrate the magnetic field lines confining the plasma to heat the core, where most fusion reactions occur. In addition, the slow modes are easily damped or snuffed out by the plasma itself. Therefore, any energy used to create slow modes is energy that is not used to heat the plasma and foster fusion reactions.

The researchers simulated the production of helicon waves and slow modes using the Petra-M computer code, a powerful and versatile program used to model electromagnetic waves in fusion devices and space plasmas. The simulations replicated conditions in the DIII-D tokamak, a doughnut-shaped plasma device operated by General Atomics for the DOE. The team performed a series of virtual experiments to test which of the following had the greatest effect on the production of slow modes—the antenna's alignment, the Faraday screen's alignment or the density of small particles known as electrons in front of the antenna.

The simulations confirmed suggestions made by previous researchers indicating that when the Faraday screen was aligned at an angle of five degrees or less from the orientation of the antenna, the screen—in effect—short-circuits the slow modes, making them fizzle out before they propagate into the plasma.

The suppression of slow modes depends greatly on how much the Faraday screen leans to the side.

"We found that when the screen's orientation exceeds five degrees by only a little bit, the slow modes grow by a great deal," said PPPL principal research physicist Masayuki Ono, one of the paper's authors. "We were surprised by how sensitive the development of slow modes was to the screen alignment."

Scientists could use this information to tweak the design of new fusion facilities to make their heating more powerful and efficient.

In the future, the scientists plan to increase their understanding of how to prevent slow modes by running computer simulations that consider more of the plasma's properties and factor in more information about the antenna.

More information: E.-H. Kim et al, Full-wave simulations on helicon and parasitic excitation of slow waves near the edge plasma, *Physics of Plasmas* (2024). [DOI: 10.1063/5.0222413](https://doi.org/10.1063/5.0222413)

Provided by Princeton Plasma Physics Laboratory

US scientists boost nuclear fusion plasma heating efficiency with metal screens



US scientists boost nuclear fusion plasma heating efficiency with metal screens

Nuclear fusion, the powerful reaction that powers the Sun, also has the potential to provide abundant clean energy on Earth.

For instance, the amount of energy produced by burning 2,400 gallons of oil or several million tons of coal can be generated by the fusion of just one gram of deuterium-tritium (a type of nuclear fusion fuel), and that too without releasing any greenhouse gases.

This is why scientists in many parts of the world are trying to [make fusion reactions practical](#) and scalable. However, it's not as easy as it sounds. For a fusion reaction, plasma is required to be heated to hundreds of millions of degrees Celsius — this is seven to eight times more than the temperature found at the Sun's core.

At first, it may seem impossible to [heat plasma](#) to such extreme temperatures, but a new study from researchers at the Princeton Plasma Physics Laboratory (PPPL) suggests that it can be achieved using a Faraday screen.

Getting rid of slow modes

One of the [methods](#) that scientists use to heat plasma is called wave heating or radio frequency (RF) heating. This approach involves using electromagnetic waves to shoot up the temperature of the plasma.

When high-frequency waves are injected into the system, they transfer their energy to the charged particle inside the plasma, which causes them to move faster and collide more frequently, leading to a sharp [increase in the plasma temperature](#).

This is similar to how microwaves in an oven interact with water molecules in food. These waves transfer energy to the molecules, causing them to vibrate rapidly. This vibration generates heat, which raises the temperature of the food.

However, this approach has a limitation that prevents the plasma from achieving the required temperature. RF heating also results in additional waves other than the ones that heat the plasma.

These extra waves, called slow modes, lead to energy losses and end up reducing the overall plasma temperature. The study authors ran some simulations that revealed a technique capable of overcoming the slow modes.

"We have performed computer simulations confirming a technique that prevents the production of the unhelpful waves, known as slow modes, boosting the heat put into the plasma and increasing the efficiency of the fusion reactions," the PPPL team [notes](#).

Special metal screens to achieve fusion

For the first time, the PPPL team ran some 2D simulations to figure out a way of reducing slow modes. During their study, they discovered that when Faraday screens (also called the [Faraday cage](#)) are placed at five-degree angles to the antenna that generates electromagnetic waves to heat plasma, slow modes are not produced.

Faraday screen which is made of conducting material, like metal works as a protective barrier blocking or reducing electromagnetic waves.

The simulations demonstrated that the screen allowed the low-frequency heating waves (called the helicon waves) from the antenna to pass into the plasma. However, slow modes were stopped.

“The simulations confirmed suggestions made by previous researchers indicating that when the Faraday screen was aligned at an angle of five degrees or less from the orientation of the antenna, the screen, in effect, short-circuits the slow modes, making them fizzle out before they propagate into the plasma,” the study authors said.

However, as the screen angle was further increased, the slow mode frequency also rose sharply. This observation suggests that plasma temperature is super sensitive to the orientation of the Faraday screen.

The researchers now plan to explore other ways to limit slow modes. These efforts will make it easier to achieve the required ultra-high temperatures needed for [fusion reactions](#).

The [study](#) is published in the journal *Physics of Plasmas*.

Researchers develop bold new process to examine materials at atomic level — here's how it could boost the energy sector

Researchers develop bold new process to examine materials at atomic level — here's how it could boost the energy sector

Researchers at the University of Virginia have made a breakthrough that could have far-reaching effects. According to an [article](#) by the UVA School of Engineering and Applied Sciences, the team, led by assistant professor Kory Burns, developed a method to reveal atomic-level details about a certain material.

Burns, and his many collaborators from multiple universities and national labs, set out to gain a better understanding of the nanoscale effects of radiation on materials. While how materials behave under irradiated conditions may not sound like it applies to everyday life, the research has the potential to understand how those materials behave under other extremes as well.

The team used [transmission electron microscopy](#), which uses a beam of electrons to create an image of a thin sample of a specimen. The [tech](#) is capable of revealing tiny details that are impossible to see with a regular microscope. The team also used [convolutional neural networks](#), which allow researchers to study changes over time from a large group of data all at once.

What makes this study so exciting is that it revealed how defects in different metals [behave differently](#). Knowing how different metals behave under different circumstances could allow manufacturers to produce metals that will perform better under those conditions.

"Defects caused by radiation at the nanoscale can significantly affect performance and structural longevity," [said](#) Burns. "By examining the fundamental interactions within materials, we can devise better strategies to extend their lifetime."

As the university article detailed, the research "promises to advance the understanding of how materials behave not only under irradiated conditions, but potentially under other types of extremes as well. Industries such as renewable

energy, space exploration, and advanced electronics stand to benefit from improved materials that can better withstand harsh environments."Developing more durable metals could have a huge impact on the clean energy industry in a variety of ways. It could lead to stronger wind turbines in the Midwest that have to endure some of the most [extreme weather](#), [like tornadoes](#), or in the [North Sea](#) that are constantly bombarded by waves.

If the planet [continues to get warmer](#), [extreme weather](#) will continue to get worse, so metals developed to handle specific conditions could become essential.

This breakthrough could also lead to longer-lasting batteries and more reliable electronics for everyday devices, [electric vehicles](#), and even life-saving medical devices.

"Our model reduces human error, accelerates analysis, and quantifies rapid reactions," Burns [said](#).

A New Alloy Could Fortify Fusion Reactors—and Lead to Endless Energy



Layered metal and oxide may finally stand the heat.© mesh cube - Getty Images

- In an experiment, prepared metal held up against corrosive coolants used in fusion reactors.

- These coolants are used because they can help to generate more of the fuel that reactors need.
- Dispersing aluminum oxide in a metal alloy can make it much stronger and more durable.

Scientists from the Institute of Science Tokyo suggest that a novel alloy with high heat tolerance could help solve a foundational problem in many planned [nuclear fusion reactors](#). A paper on this research [appears now](#) in the journal *Corrosion Science*.

The team started with an existing high-heat alloy—from a category partly trademarked as Kanthal—made of [iron](#), chromium, and aluminum. And instead of a traditional structure, they intersperse molecules of oxides, which combine (in this case) metals and oxygen. Finally, the oxide dispersion strengthened (ODS) alloy was coated with even more aluminum oxide to test the combined heat tolerance of the fully assembled material.

The treated [alloy](#) held up against a turbulent liquid metal at 600°C (over 1,100°F). They also tested the coating against exfoliation and found that, even after the hot metal bath, the coating held tight to the ODS alloy base. The researchers say that even the bare version of the ODS alloy, without their additional coating of aluminum oxide, spontaneously formed its own outer layer that they believe contributed to its high heat tolerance. Basically, it didn't melt, it didn't come off, and it made itself stronger.

If you follow fusion reactor research, you may already have a smart question in mind: Why does 600°C matter when these reactors plan to reach a million degrees or more? Well, this research is about coolants, rather than the temperatures reached by the star-hot plasma stream in a [tokamak](#) or [stellarator](#) fusion reactor. Scientists enlist liquid metals, like the lithium-lead alloy used for the exposure test in this experiment, to do two things. First, they help enable the reaction that creates more deuterium or tritium fuel, which is (unfortunately) called “breeding” in the industry. (Breeding fusion fuel is a huge bottleneck, with companies like Wisconsin-based SHINE [focusing on scaling it up](#) using technology.) And second, they act as shielding coolants.

But, the researchers explain, heavy liquid metal coolants (HLMCs) “such as lead (Pb), lead-bismuth eutectic alloy (PbBi) and lithium lead alloy (LiPb) are corrosive

fluids, though they have excellent nuclear and thermal properties.” Corrosion, the namesake of this entire journal, is the process by which even a relatively stable metal seeks and absorbs oxygen particles and eventually oxidizes—meaning it forms pockets of oxides. [Rust](#) is the most common example of corrosion, but oxidation affects everything from your car to your guacamole.

Since corrosion is inherent in the use of these liquid metal coolants, scientists have sought a way to seal any materials that touch them for protection. In this experiment, the prepared sample of ODS alloy with aluminum oxide coating held up against corrosion—a success that will create a base for further development and [exploration](#). This could be the next [Teflon](#) or [Bondo](#) in terms of controlling and preventing undesirable contact like rust or, you know, stuck-on scrambled eggs.

If the idea of aluminum and oxygen together doesn't exactly scream “withstand 1,100°F,” just remember that the crystal form of aluminum oxide becomes rubies and sapphires, depending on which trace impurities are in the mix. The plain version of this mineral, corundum, is [an industrial abrasive](#) that's a 9 on the hardness scale (diamond, [the hardest natural substance](#), is a 10).

Any successful nuclear fusion power plant will need its reactors to run for an extended period of time in order to generate real net [energy](#). These reactors require extraordinary energy to even get up and running, and today, their progress is stopped after a short time by logistical problems stemming from the difficulties of containment. Indeed, a layered Andes mint of strong metal and industrial ruby could buy these reactors a bit more time—something they desperately need.

How Do Tokamaks Work And Are They The Future Of Energy?



A 3D illustration of a Tokamak fusion reactor. - Image Credit: Efman/Shutterstock.com© IFL Science

Vast amounts of money and brainpower in the effort to achieve sustained, controlled, nuclear fusion. Many designs have been proposed, and even tried, but tokamaks are comfortably the most popular. The name may be familiar, but not everyone knows what they are.

What Is A Tokamak?

Stars heat matter to such high temperatures that electrons escape their atoms, creating plasma. A tokamak is a device designed to hold plasma so we can bend it to our will, which ultimately is to replicate the fusion that takes place at the core of stars.

On Earth, a plasma would normally interact with its surroundings, losing energy to them and cooling down, even if it didn't melt the walls. To avoid this, tokamaks use powerful magnetic fields to hold the plasma in a torus, a shape most familiar to us from donuts (not the sort with jam centers).

Many smaller tokamaks have been built so we can do basic research on the behavior of plasma. However, the major reason the world has spent tens of billions of dollars building larger and more powerful versions is the hope we can eventually get enough plasma inside a tokamak to fuse to produce useful amounts of energy. The [sun achieves nuclear fusion](#) through the immense force gravity applies at its core, but it takes a star's worth of matter to do that. It is hoped tokamaks can allow us to do something similar without all that mass.

When the nuclei of small atoms fuse, the resulting nucleus is slightly lighter than the components that went into making it. The lost mass is released as energy. By the famous equation $E=mc$, a very small amount of mass becomes a great deal of energy. When four hydrogen atoms (or two deuterium atoms) fuse to become one helium atom, the mass loss is so tiny, the energy released is still small. However, if you can manage to fuse a steady supply of atoms, the energy released becomes immense.

How Should Tokamaks Work?

Since plasma consists of atoms whose electrons have been stripped away, it is positively charged. The motion of an electrically charged material can be controlled through electrical or magnetic fields. Tokamaks exploit this to keep plasma within the donut shape without letting it touch anything and lose energy.

To achieve fusion, the temperature of plasma needs to be very high. Like a gas, plasma will expand if not contained, and the hotter it is, the more pressure is required to stop it escaping. That means the fields required to make Tokamak's work have to be enormous.

These mighty fields are produced by wrapping the torus in conductive coils and putting vast amounts of current through them.

Once the field is sufficient to keep the plasma where it is needed, a pulse of energy is delivered, for example with lasers, ion beams or a burst of electrical current known as a Z-pinch. Atomic nuclei get squeezed together so hard that in some cases it overcome the repulsive forces between them, causing them to fuse.

At least some of the leftover energy is released as heat. In theory, this can be captured to heat a liquid to become gas to drive a turbine. Using steam to drive turbines is the dominant way of producing electricity today, but of course the process is a lot more difficult when the plasma is already hot enough to destroy anything it touches. A popular solution is to fuse [deuterium](#) and [tritium](#) nuclei together. Besides producing helium and heat, the reaction produces neutrons, which carry away a lot of the energy at great speed. Not being electrically charged, neutrons can escape the magnetic field, and heat surrounding materials.

What Have Tokamaks Done?

Tokamaks have been used to fuse nuclei for decades, but you might have noticed none of the electricity in your wires is made this way. That's because enormous amounts of energy are required to heat and contain the plasma, and then induce the pulses that initiate the fusion process.

Currently, far more energy is supplied than produced.

In 2022 a great deal of fuss was made about what was [described as](#) the first controlled fusion reaction with a positive energy gain, that is its energy output was greater than its input. The National Ignition Facility (NIF), where the work was done, was not a tokamak, but several tokamaks are [hot on its tail](#).

However, while the NIF claim [was true](#), much of the coverage was very misleading. One acknowledged issue is that the reaction lasted more than a few seconds, but the problems were bigger than that.

The reaction's output only exceeded input if you looked at the single stage where lasers put energy in and power came out. This ignored all the energy required to [power the facility to get there](#), and the challenges of harvesting the energy produced in the fusion reaction.

Consider the later part of the process. Coal and gas-fired power stations are really only about [33 percent efficient](#). A great deal of heat is produced when the fuel is burned, and

while some of this is used to drive a turbine, a lot is wasted. Some are released as hot flue gasses or steam into the environment, some end up heating up the walls of the power station, and the turbine is not perfectly efficient at turning its rotational energy into electricity.

The challenges of capturing the heat produced in a tokamak or other fusion reactor will be even greater, so it's almost certain the efficiency will be lower still. If two-thirds of the heat the reactor produces never gets turned into electricity, then we need to get three times as much heat out for the energy put in to make the reaction happen before its energy positive in practical terms.

So far, no tokamak has come close to that, and it's unlikely one will for many years.

Even once positive in terms of useful energy, tokamaks will have a fair way to go before they're widely used. Imagine if you put a gigawatt of electricity into a fusion power plant and got 1.1 GW out. You're ahead, but you're getting out less energy than most existing power stations produce, or a large wind farm. Considering the enormous cost of building a machine like that, you're going to want a much better return.

Are Tokamaks The Future Of Energy?

There is a cliché that practical fusion power is twenty years away - and has been for twenty years. This is somewhat true, except that boosters have been promising fusion power within two decades for sixty years now, not twenty. Every now and then the promises get more ambitious, such as the time that Lockheed Martin promised a workable fusion reactor [within ten years](#). That was ten years ago, and there is no sign of delivery.

That history means that only the very naïve would take predictions of imminent fusion success at face value. Nevertheless, practical nuclear fusion is something we will almost certainly achieve eventually, barring complete civilization collapse. Whether it will dominate our energy production is a much more doubtful proposition.

Fusion first came to be hailed as the future of energy in the 1950s when the major cost of producing energy was in the fuel. Most of the world's electricity came from coal, which was dirty and dangerous to mine. As the best coal sites got used up, the cost would eventually rise further.

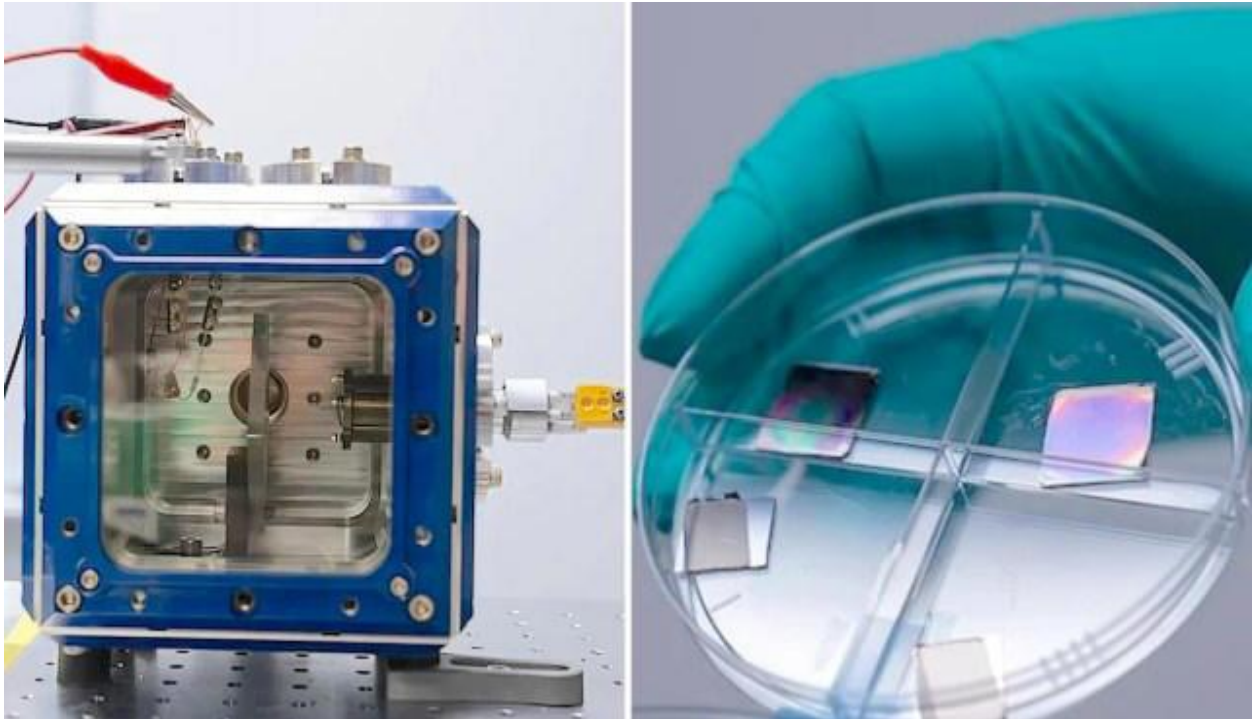
Nuclear power based on fissioning uranium (or thorium) meant much cheaper and more abundant fuel, but eventually this would run out as well, people reasoned, in addition to the problem of disposing of the waste. In nuclear fusion the fuel, available from sea water, would cost almost nothing. Once we worked out how to do it, how could fusion not be the path to limitless energy too cheap to meter?

Today, however, a rising share of our electricity comes from other sources where the fuel is free, in the form of sunlight and wind. That doesn't mean the electricity cost is nothing, because the installation costs have to be repaid.

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Scientists push boundaries with high-tech device that turns heat source into readily available energy — here's how it works



It can stabilize renewable energy grids by storing surplus energy during periods of low demand and releasing it during peak usage.

Scientists at Rice University are [working](#) to turn waste heat from industrial processes into electricity.

They've developed a cutting-edge device that turns heat into electricity with an impressive 60% efficiency, a breakthrough that could redefine how we store and use renewable energy. According to [Interesting Engineering](#), this innovation marks a significant leap toward a cleaner and more sustainable energy landscape.

Study co-author Ciril Samuel Prasad described the device, explaining that it "maximizes energy conversion," making it one of the most efficient clean energy solutions developed to date.

Here's how it works: The researchers combined tiny silicon structures with a base made of tungsten (a very strong and heat-resistant metal) to create a thermal

emitter. When heated, it emits light, which is then converted into electricity by solar-like photovoltaic panels.

These silicon "nanocylinders" are designed to interact, or "talk," to each other, releasing the most efficient light. This process minimizes energy loss and majorly boosts energy performance.

Why is this such a big deal? Batteries, while essential to powering everything from smartphones to energy grids, come with some baggage. Mining for battery materials has a [serious impact on ecosystems](#), according to the Environmental Protection Agency, and trashed batteries [leave behind toxic waste](#). Plus, their short lifespans mean constant replacements, which means more environmental harm.

"We essentially showed how to achieve the best possible performance for the emitter given realistic, practical design constraints," Prasad said.

This new thermal emitter addresses these issues by offering a more efficient alternative. Using low-cost, durable materials, it can stabilize renewable energy grids by storing surplus energy during periods of low demand and releasing it during peak usage.

For example, the device could make renewable energy grids more reliable by holding extra power from [solar panels](#) or wind turbines during the day and delivering it when it's needed in the evening, when energy use spikes as people return home.

The International Renewable Energy Agency says breakthroughs like this, along with others such as [solar panels that work at night](#) or [China's flywheel energy storage project](#), are key to cutting back on [dirty energy](#) use and creating stronger and more reliable power systems.

"Further international cooperation is vital to deliver fit-for-purpose grids, sufficient energy storage and faster electrification, which are integral to move clean energy transitions quickly and securely," Executive Director of the International Energy Agency Fatih Birol said in an [IEA report](#).

This new way of storing energy could deliver cleaner, more affordable energy to cities, businesses, and homes. Researchers at Rice University believe it could be

widely available in five to 10 years, making renewable energy more practical and accessible.

A photograph of a young man in a laboratory setting, wearing a futuristic, glowing exoskeleton or sensor suit. The suit is composed of a network of white and blue lights, with a central green glow on the chest area. The background shows a computer monitor and other lab equipment. The text "MADE USING AI" is visible on the left side of the image.

MADE USING AI

Your Body Could Be An Electricity Generator - This New South Korean Tech Will Change The Future!

 **FOSSBYTES**

Researchers at DGIST in South Korea have developed a highly efficient energy harvester that converts body movements into electrical energy, achieving 280 times higher efficiency than traditional devices.

The device uses the piezoelectric effect, where materials generate an electrical charge in response to mechanical stress, enabling energy capture from movements like walking and bending.

This new tech promises a new method for sustainable energy generation, harnessing the power of everyday body motions to produce electricity.

How Do Tokamaks Work And Are They The Future Of Energy?



A 3D illustration of a Tokamak fusion reactor. - Image Credit: Efman/Shutterstock.com© IFL Science

Vast amounts of money and brainpower in the effort to achieve sustained, controlled, nuclear fusion. Many designs have been proposed, and even tried, but tokamaks are comfortably the most popular. The name may be familiar, but not everyone knows what they are.

What Is A Tokamak?

Stars heat matter to such high temperatures that electrons escape their atoms, creating plasma. A tokamak is a device designed to hold plasma so we can bend it to our will, which ultimately is to replicate the fusion that takes place at the core of stars.

On Earth, a plasma would normally interact with its surroundings, losing energy to them and cooling down, even if it didn't melt the walls. To avoid this, tokamaks use powerful magnetic fields to hold the plasma in a torus, a shape most familiar to us from donuts (not the sort with jam centers).

Many smaller tokamaks have been built so we can do basic research on the behavior of plasma. However, the major reason the world has spent tens of billions of dollars building larger and more powerful versions is the hope we can eventually get enough plasma inside a tokamak to fuse to produce useful amounts of energy. The [sun achieves nuclear fusion](#) through the immense force gravity applies at its core, but it takes a star's worth of matter to do that. It is hoped tokamaks can allow us to do something similar without all that mass.

When the nuclei of small atoms fuse, the resulting nucleus is slightly lighter than the components that went into making it. The lost mass is released as energy. By the famous equation $E=mc$, a very small amount of mass becomes a great deal of energy. When four hydrogen atoms (or two deuterium atoms) fuse to become one helium atom, the mass loss is so tiny, the energy released is still small. However, if you can manage to fuse a steady supply of atoms, the energy released becomes immense.

How Should Tokamaks Work?

Since plasma consists of atoms whose electrons have been stripped away, it is positively charged. The motion of an electrically charged material can be controlled through electrical or magnetic fields. Tokamaks exploit this to keep plasma within the donut shape without letting it touch anything and lose energy.

To achieve fusion, the temperature of plasma needs to be very high. Like a gas, plasma will expand if not contained, and the hotter it is, the more pressure is required to stop it escaping. That means the fields required to make Tokamak's work have to be enormous.

These mighty fields are produced by wrapping the torus in conductive coils and putting vast amounts of current through them.

Once the field is sufficient to keep the plasma where it is needed, a pulse of energy is delivered, for example with lasers, ion beams or a burst of electrical current known as a Z-pinch. Atomic nuclei get squeezed together so hard that in some cases it overcome the repulsive forces between them, causing them to fuse.

At least some of the leftover energy is released as heat. In theory, this can be captured to heat a liquid to become gas to drive a turbine. Using steam to drive turbines is the dominant way of producing electricity today, but of course the process is a lot more difficult when the plasma is already hot enough to destroy anything it touches. A popular solution is to fuse [deuterium](#) and [tritium](#) nuclei together. Besides producing helium and heat, the reaction produces neutrons, which carry away a lot of the energy at great speed. Not being electrically charged, neutrons can escape the magnetic field, and heat surrounding materials.

What Have Tokamaks Done?

Tokamaks have been used to fuse nuclei for decades, but you might have noticed none of the electricity in your wires is made this way. That's because enormous amounts of energy are required to heat and contain the plasma, and then induce the pulses that initiate the fusion process.

Currently, far more energy is supplied than produced.

In 2022 a great deal of fuss was made about what was [described as](#) the first controlled fusion reaction with a positive energy gain, that is its energy output was greater than its input. The National Ignition Facility (NIF), where the work was done, was not a tokamak, but several tokamaks are [hot on its tail](#).

However, while the NIF claim [was true](#), much of the coverage was very misleading. One acknowledged issue is that the reaction lasted more than a few seconds, but the problems were bigger than that.

The reaction's output only exceeded input if you looked at the single stage where lasers put energy in and power came out. This ignored all the energy required to [power the facility to get there](#), and the challenges of harvesting the energy produced in the fusion reaction.

Consider the later part of the process. Coal and gas-fired power stations are really only about [33 percent efficient](#). A great deal of heat is produced when the fuel is burned, and while some of this is used to drive a turbine, a lot is wasted. Some are released as hot flue gasses or steam into the environment, some end up heating up the walls of the power station, and the turbine is not perfectly efficient at turning its rotational energy into electricity.

The challenges of capturing the heat produced in a tokamak or other fusion reactor will be even greater, so it's almost certain the efficiency will be lower still. If two-thirds of the heat the reactor produces never gets turned into electricity, then we need to get three times as much heat out for the energy put in to make the reaction happen before its energy positive in practical terms.

So far, no tokamak has come close to that, and it's unlikely one will for many years.

Even once positive in terms of useful energy, tokamaks will have a fair way to go before they're widely used. Imagine if you put a gigawatt of electricity into a fusion power plant and got 1.1 GW out. You're ahead, but you're getting out less energy than most existing power stations produce, or a large wind farm. Considering the enormous cost of building a machine like that, you're going to want a much better return.

Are Tokamaks The Future Of Energy?

There is a cliché that practical fusion power is twenty years away - and has been for twenty years. This is somewhat true, except that boosters have been promising fusion power within two decades for sixty years now, not twenty. Every now and then the promises get more ambitious, such as the time that Lockheed Martin promised a workable fusion reactor [within ten years](#). That was ten years ago, and there is no sign of delivery.

That history means that only the very naïve would take predictions of imminent fusion success at face value. Nevertheless, practical nuclear fusion is something we will almost certainly achieve eventually, barring complete civilization collapse. Whether it will dominate our energy production is a much more doubtful proposition.

Fusion first came to be hailed as the future of energy in the 1950s when the major cost of producing energy was in the fuel. Most of the world's electricity came from coal, which was dirty and dangerous to mine. As the best coal sites got used up, the cost would eventually rise further.

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Researchers achieved stunning results after transforming common waste into vital material for futuristic batteries: 'Opening up new possibilities'



While lithium-ion batteries have great energy density ... supercapacitors are more adept at rapid charging and energy delivery.

The development of efficient [energy storage](#) solutions is key to our sustainable energy future, and a recent study has shown that waste oil can be repurposed to help support that goal.

Researchers from Tongji University and the University of Shanghai for Science and Technology have introduced an innovative method for transforming oil into

high-quality electrode materials essential in building supercapacitors, as Tech Xplore [detailed](#).

Supercapacitors have the ability to charge and discharge energy very quickly without substantially affecting long-term performance, something that can be difficult for today's [lithium-ion batteries](#).

However, Tech Xplore noted there have been challenges in meeting the growing demand for the high-quality materials needed to build supercapacitors, as they require a balance of conductivity and surface area.

To resolve this, the outlet explained, scientists have explored "advanced carbon materials with intricate porous structures and strategically placed nitrogen atoms, a process known as heteroatom doping," and waste oil is a great source.

"By using waste oil as a precursor, we're not only [recycling](#) waste into a valuable resource but also creating a supercapacitor material with exceptional electrochemical properties," Dr. Suyun Xu, a leading researcher on the project, said.

"Our approach optimizes the pore structure and uses nitrogen doping to elevate the performance of supercapacitors, opening up new possibilities for sustainable, high-efficiency energy storage."

While lithium-ion batteries, such as those used to [power electric vehicles](#), have great energy density, supercapacitors are more adept at rapid charging and energy delivery in short bursts, [according to](#) Futurebridge. That's why [some automakers](#) employ them to handle the energy input from regenerative braking and deliver it to help boost acceleration in some EVs and fuel-cell hybrids.

Supercapacitors have been found to recover [53%](#) more energy from braking than traditional batteries, which helps boost the overall efficiency of EVs. This also lowers the [heat burden](#) on lithium-ion batteries, helping to extend their lifespan.

The underused energy source under the Earth's surface that could mean a carbon-free future



Scientists have discovered vast underground reserves of a clean energy source capable of replacing fossil fuels and helping feed the world for centuries.© Pixabay

A recent scientific discovery could change the course of the global energy crisis: **under the earth's surface** there are vast reserves of **natural hydrogen, a clean and sustainable resource**.

According to a study published in Science Advances, these reserves could be the key to **replacing fossil fuels** and **feeding the world for the next 200 years**.

Until recently it was believed that hydrogen **could not accumulate underground** due to its volatile nature, but recent **research has shown otherwise**.

Computer models suggest the planet is home to approximately **6.2 trillion tons of hydrogen** trapped in rocks and underground deposits, a figure **26 times greater than known oil reserves**.

READ ALSO: [No longer science fiction, scientists test quantum teleportation](#)

The promise of natural hydrogen

Hydrogen, known for being a **clean, emissions-free energy source**, can power vehicles, industrial processes and generate electricity.

According to Geoffrey Ellis, a geochemist at the U.S. Geological Survey and lead author of the study, even a small fraction of these reserves- about 2%- would be **enough to meet global energy demand** and move toward a **carbon-free future**.

The first signs of significant accumulations of natural hydrogen have been found in places such as **West Africa and a chrome mine in Albania**.

These discoveries have opened up new possibilities for the use of this resource, provided that **technologies are developed** that allow the reserves to be **located and extracted efficiently**.

Hydrogen as an energy source: Challenges and opportunities

While calculations indicate there is **more than enough hydrogen** to meet the planet's energy needs, scientists acknowledge much of the reserves may be **too deep or found in inaccessible locations**.

Some deposits may be **too small to justify extraction**. But these limitations do not negate hydrogen's transformative potential.

A crucial advantage of natural hydrogen is its **stability in the reservoirs** where it is found, eliminating the need for costly storage and transportation systems. In addition, its ability **to release twice as much energy** as known natural gas reserves makes it an attractive alternative for a variety of energy sectors.

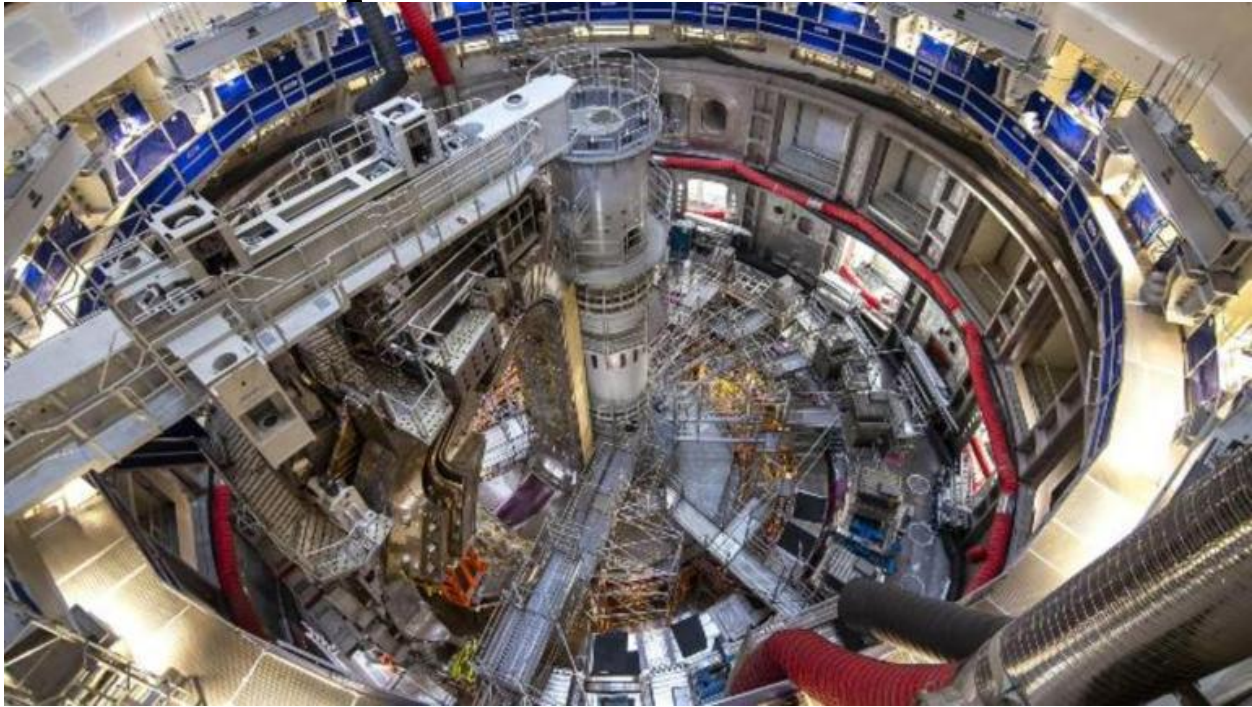
A future powered by hydrogen

With global demand for hydrogen expected to increase fivefold by 2050, experts predict the resource will account for **up to 30% of energy supply** in some sectors.

Most hydrogen is **currently produced artificially** through processes such as electrolysis, but the **discovery of natural reserves** could significantly reduce costs and accelerate the transition to clean energy.

In the coming months, researchers hope to more precisely identify **hydrogen deposits in the United States** and other countries, ushering in a new energy era. If these findings are confirmed, **natural hydrogen could become the key to abandoning fossil fuels** and tackling climate change once and for all.

Scientists ‘surf’ plasma waves to tame nuclear eruptions in fusion reactors



Scientists ‘surf’ plasma waves to tame nuclear eruptions in fusion reactors

One of the most critical challenges in realizing nuclear fusion is the confinement of plasmas, which are the ultra-hot, ionized gases where fusion reactions occur.

“Achieving high confinement is key to the development of nuclear fusion power plants and is the final aim of ITER, the largest tokamak in the world currently under construction in Cadarache (France),” said the researchers of a new study.

“On the road to a magnetic fusion power plant, a good confinement of a burning plasma, at temperatures $> 10^8$ K and particle densities $> 10^{20} \text{ m}^{-3}$, is mandatory,” explained the study.

The fusion plasmas are notoriously unstable and prone to eruptions known as Edge Localized Modes (ELMs), which are similar to solar flares.

These ELMs, which are magnetohydrodynamic waves (MHD), can cause significant energy and particle losses. They can damage the walls of [fusion devices](#) and hinder the efficiency of fusion reactions.

“However, a detailed understanding of the ELM behaviour and consequences in a burning plasma with a notable fraction of energetic (suprathermal) ions is missing,” added [the study](#).

Complex interplay between ELMs, energetic ions

In this regard, a team of scientists has made a breakthrough by revealing a complex interplay between ELMs and energetic ions, a key component of fusion [plasmas](#).

“Energetic (suprathermal) particles constitute an essential source of momentum and energy, especially in future burning plasmas,” asserted the team in a [press release](#).

“They must be well confined to guarantee a self-sustaining fusion reaction.”

The team, working within the EUROfusion consortium, discovered that these energetic ions can significantly influence the behavior of ELMs.

“The effect is analogous to a surfer riding the wave. The surfer leaves footprints on the wave when riding it. In a plasma, the energetic particle interacts with the MHD wave (the ELM) and can change its spatio-temporal pattern,” said lead author Jesús José Domínguez-Palacios Durán.

Offering a path to clean and limitless energy source

This potentially offers a new way to control these disruptive events. Notably, the team combined experiments at the ASDEX Upgrade tokamak in Germany with advanced computer simulations using a code called MEGA.

This allowed them to observe the interaction between ELMs and energetic ions in detail and unravel the underlying physics.

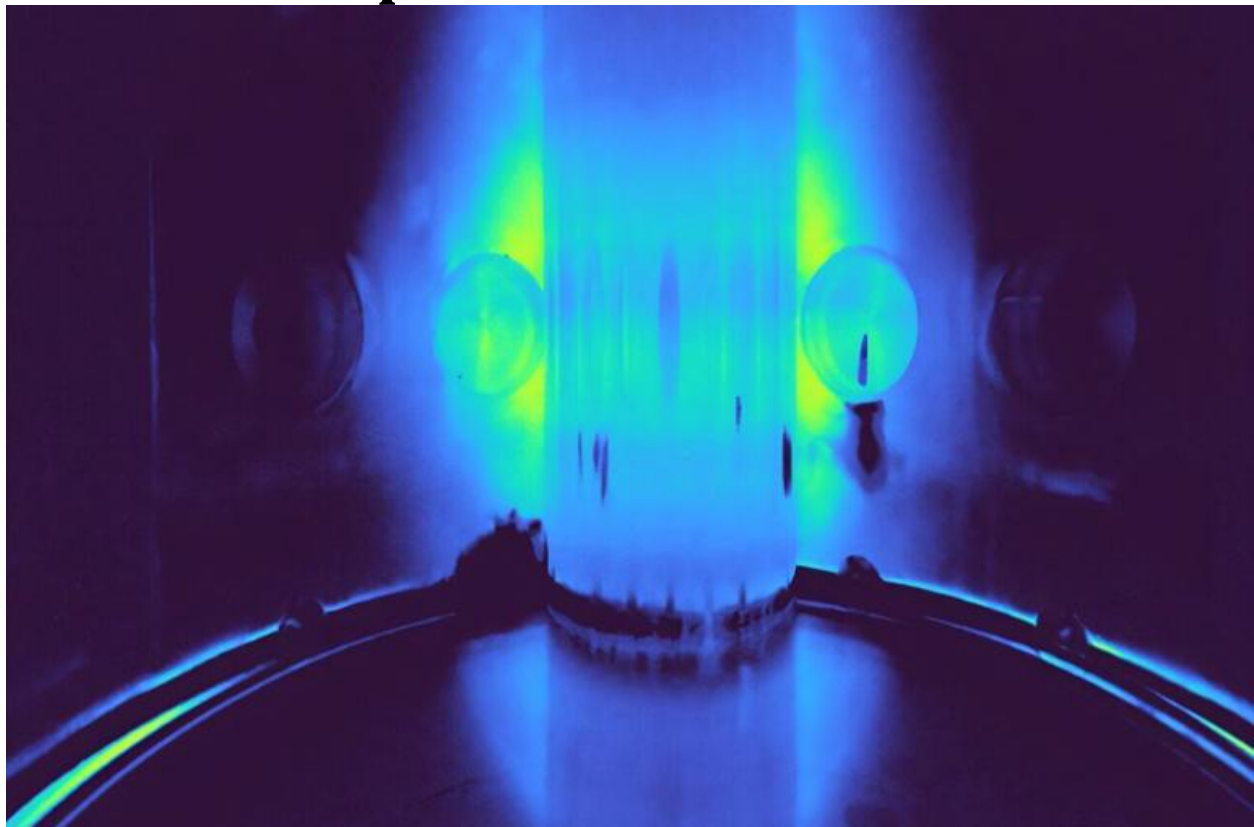
“The results indicate that the spatio-temporal structure of ELMs is largely affected by the energetic particle population and indicate that the interaction mechanism between ELMs and energetic particles is a resonant energy exchange between them,” highlighted the press release.

Nuclear fusion, the process that powers the sun, holds immense promise as a clean and virtually limitless energy source for the future.

The latest work represents a significant step forward in the quest for fusion energy, offering hope for a future powered by a clean and abundant energy source. By manipulating the energetic ion population, scientists may be able to tame the ‘solar flares’ of fusion plasmas and unlock the full potential of this clean energy source.

“Our results can have important implications for the optimization of ELM control techniques.”

SMART: One step closer to nuclear fusion with its first plasma

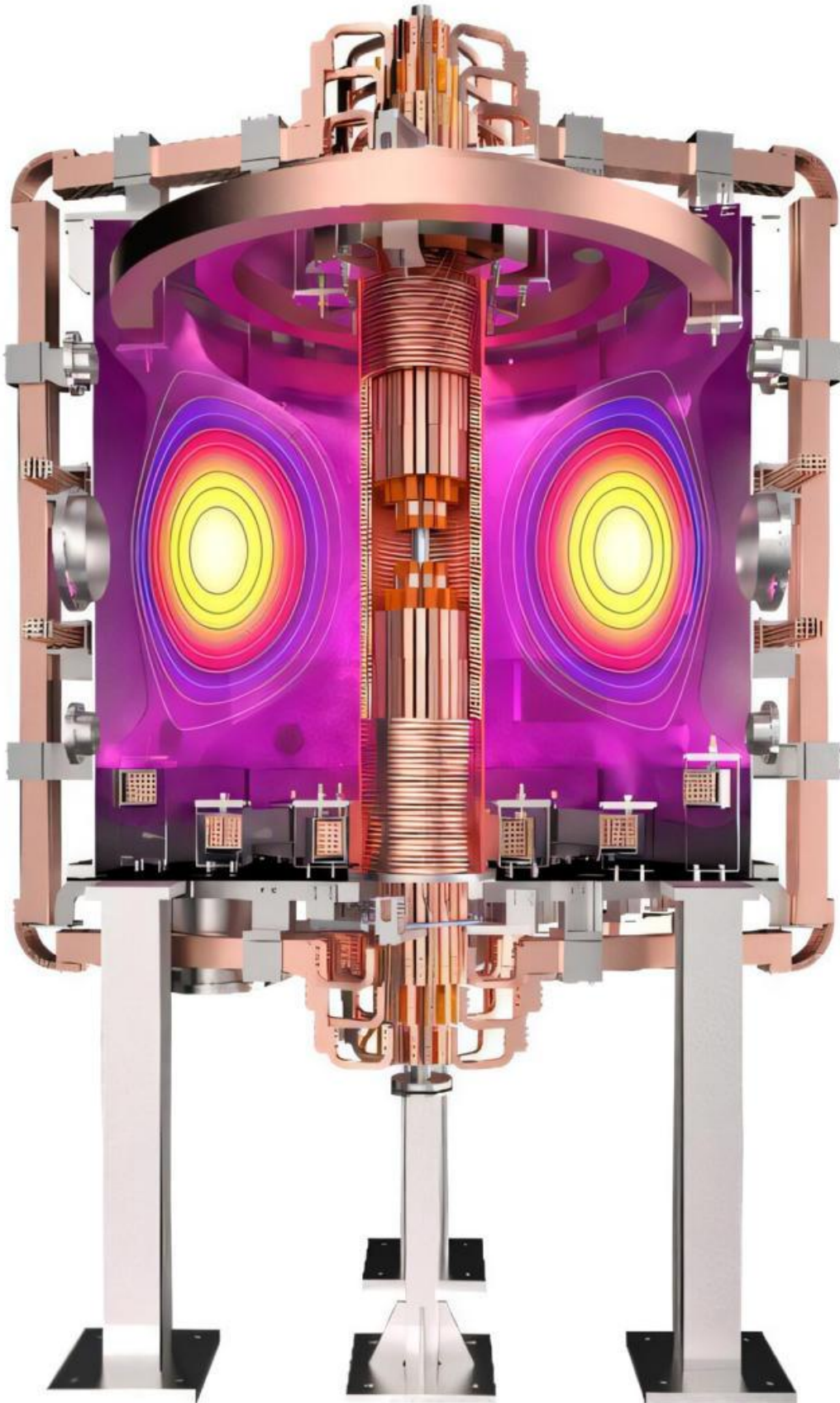


First tokamak plasma at the SMall Aspect Ratio Tokamak—SMART—recorded with a fast-framing camera in the visible spectral range. Credit: University of Seville

In a pioneering approach to achieve fusion energy, the SMART device has successfully generated its first tokamak plasma. This step brings the international fusion community closer to achieving sustainable, clean, and virtually limitless energy through controlled fusion reactions.

The work is [published](#) in the journal *Nuclear Fusion*.

The SMART tokamak, a state-of-the-art experimental fusion device designed, constructed and operated by the Plasma Science and Fusion Technology Laboratory of the University of Seville, is a unique spherical tokamak due to its flexible shaping capabilities. SMART has been designed to demonstrate the unique physics and engineering properties of Negative Triangularity shaped plasmas towards compact fusion power plants based on Spherical Tokamaks.



Render of the SMART tokamak with a Negative Triangularity fusion plasma inside. Credit: University of Seville

Prof. Manuel García Muñoz, Principal Investigator of the SMART tokamak, stated, "This is an important achievement for the entire team as we are now entering the operational phase of SMART. The SMART approach is a potential game changer with attractive fusion performance and power handling for future compact fusion reactors. We have exciting times ahead."

Prof. Eleonora Viezzer, co-PI of the SMART project, adds, "We were all very excited to see the first magnetically confined plasma and are looking forward to exploiting the capabilities of the SMART device together with the international scientific community. SMART has awoken great interest worldwide."

When negative becomes positive and compact

The triangularity describes the shape of the plasma. Most tokamaks operate with positive triangularity, meaning that the plasma shape looks like a D. When the D is mirrored, the plasma has negative triangularity.

Negative triangularity plasma shapes feature enhanced performance as they suppress instabilities that expel particles and energy from the plasma, preventing severe damage to the tokamak wall.

Besides offering high fusion performance, negative triangularity also features attractive power handling solutions, given that it covers a larger divertor area for distributing the heat exhaust. This also facilitates the engineering design for future compact fusion power plants.

Fusion2Grid aimed at developing the foundation for the most compact fusion power plant

SMART is the first step in the Fusion2Grid strategy led by the PSFT team and, in collaboration with the international fusion community, is aimed at the most compact and most efficient magnetically confined fusion power plant based on Negative Triangularity shaped Spherical Tokamaks.

SMART will be the first compact spherical tokamak operating at fusion temperatures with negative triangularity shaped plasmas.

The objective of SMART is to provide the physics and engineering basis for the most compact design of a fusion power plant based on high-field Spherical Tokamaks combined with Negative Triangularity. The solenoid-driven plasma represents a major achievement in the timeline of getting SMART online and advancing towards the most compact fusion device.

More information: D.J. Cruz-Zabala et al, Performance prediction applying different reduced turbulence models to the SMART tokamak, *Nuclear Fusion* (2024). [DOI: 10.1088/1741-4326/ad8a70](https://doi.org/10.1088/1741-4326/ad8a70)

Provided by University of Seville

China's 'artificial sun' sets nuclear fusion record, runs 1,006 seconds at 180 million°F



China's 'artificial sun' sets nuclear fusion record, runs 1,006 seconds at 180 million°F

The Experimental Advanced Superconducting Tokamak (EAST) – also called ‘artificial sun’ – has achieved the milestone of 1,006 seconds of operations for sustained plasma temperature above 180 million degrees Fahrenheit (100 million degrees Celsius).

The ‘artificial sun’ is now capable of replicating the operational environment of a future nuclear fusion power plant, as per Chinese scientists.

China says it is a world record for the experimental device which is part of China’s ‘artificial sun’ project – which aims to make nuclear fusion reactors a commercial reality.

The breakthrough achieved on Monday has surpassed the situations needed for future nuclear fusion reactors, as per China.

China’s ‘artificial sun’ passes 1,000 seconds benchmark

As per a [release by](#) the State Council Information Office of China, the 1,000-second benchmark is considered an important step in nuclear fusion research.

The success has been achieved by the Institute of Plasma Physics under the Chinese Academy of Sciences in Hefei, east China’s Anhui Province.

It surpasses the [earlier record](#) set by EAST itself in 2023 – when the ‘artificial sun’ ran for 403 seconds non-stop. Prior to this, the record stood at 101 seconds, which was achieved in May 2021.

Nuclear fusion, which is the source of the energy released from the Sun is considered the ultimate energy source even on Earth since the process does not create any carbon emissions or radioactive material as a by-product.

When hydrogen atoms are superheated to temperatures above 180 million degrees Fahrenheit, the resulting plasma creates conditions that allow the atoms to merge and form helium, releasing vast amounts of energy during this process.

The 180 million degrees Fahrenheit is essential for successfully generating electricity, along with stable long-term operation, and ensuring controllability in nuclear fusion devices.

“A fusion device must achieve stable operation at high efficiency for thousands of seconds to enable the self-sustaining circulation of plasma, which is critical for the continuous power generation of future fusion plants,” said Song Yuntao, [ASIPP director](#), as per a report by China’s state news agency Xinhua.

Upgrades in EAST and contribution to ITER

As per [the release](#), several EAST systems have been upgraded since the last round of experiments. One of these is the heating system, which earlier used to operate at the equivalent of nearly 70,000 household microwave ovens. It has now doubled its power output.

The [final goal](#) of the ‘artificial sun’ is to create nuclear fusion like the sun to provide an endless, clean energy source. It also aims to provide systems needed for space exploration beyond the solar system.

China joined the International Thermonuclear Experimental Reactor (ITER) program in 2006 as its seventh member. Beijing is responsible for approximately 9 percent of the project’s construction, and ASIPP is the main unit of its mission.

ITER, which is being built in southern France, will be the world’s largest magnetic confinement plasma physics experiment device and the largest experimental tokamak nuclear fusion reactor, once completed.

The achievements of EAST will [contribute towards](#) the ITER and China Fusion Engineering Test Reactor (CFETR).

“We hope to expand international collaboration via EAST and bring fusion energy into practical use for humanity,” said Song.

US 300-megawatt boiling water nuclear reactor gets coalition support for deployment



US 300-megawatt boiling water nuclear reactor gets coalition support for deployment

GE Hitachi Nuclear Energy (GEH), a business of GE Vernova, has joined the coalition of utility companies that are working to accelerate the deployment of BWRX-300 small modular reactors in the United States.

The coalition is led by the Tennessee Valley Authority (TVA), and it includes partners such as Bechtel, BWX Technologies, Duke Energy, Electric Power Research Institute (EPRI), GEH, Indiana Michigan Power – an AEP company, Oak Ridge Associated Universities, Sargent and Lundy, Scot Forge, other utilities, and advanced nuclear project developers and the State of Tennessee.

The coalition has submitted an application for \$800 million in funding from the U.S. Department of Energy's Generation III+ SMR program.

A Generation III+ SMR is defined as a nuclear reactor that uses light water as a coolant and low-enriched uranium fuel, with a single-unit net electrical power output of 50-350 MW.

GE Hitachi joins coalition and other plans for SMR

TVA has selected the BWRX-300 SMR for potential deployment at the Clinch River Site near Oak Ridge, Tennessee. If the funding is approved, TVA plans to accelerate construction of the first SMR, with commercial operations planned for 2033.

“Nuclear power has a key role to play in reaching a cleaner and more secure energy future,” said Scott Strazik, CEO, GE Vernova.

“Funding from this grant would play a critical role in the path forward, and we look forward to working with TVA and this strong team of utility and supply chain partners to accelerate the roll-out of small modular reactors in the United States.”

GEH also said that Duke Energy has entered into an agreement to invest in activities to advance the standard design and licensing of the BWRX-300 SMR technology. Further, American Electric Power (AEP) has selected the BWRX-300 for potential deployment at the Indiana Michigan Power Rockport Plant in Spencer County, Indiana.

“On the heels of the significant progress that is occurring with the deployment of the first BWRX-300 at Ontario Power Generation’s Darlington site, these announcements signify the growing confidence the industry has in our SMR technology,” [said Mavi Zingoni](#), CEO, GE Vernova’s Power businesses.

BWRX-300 SMR’s specifications

An [advanced reactor](#), the BWRX-300 uses natural circulation and passive cooling isolation condenser systems to promote simple and safe operating rhythms.

It is a boiling water reactor that can supply 300 MW electricity to the grid. Apart from this, it can also provide hot water and steam that can be used for district heating, clean hydrogen and fuel production, reverse osmosis, and direct air capture.

It has a design life of 60 years, and the refueling cycle is 12 to 24 months. [It uses](#) commercially available fuel, and has a simplified configuration, which results in less concrete and steel needed for construction.

The BWRX-300 has a 10th generation design [which builds on](#) real-world boiling water reactor operating experience. It uses natural circulation and passive cooling isolation condenser systems to promote simple and safe operating rhythms.

Moreover, the steam condensation and gravity allow the SMR to cool itself for a minimum of seven days without power or operator action.

Earlier in December 2024, the BWRX-300 [had completed](#) Step 1 of the Generic Design Assessment (GDA) process in the United Kingdom. During Step 2, the team will be assessing the underpinning fundamentals of the BWRX-300, including identifying any specific environmental protection issues or concerns.

Nuclear fusion breakthrough brings us closer to clean limitless power



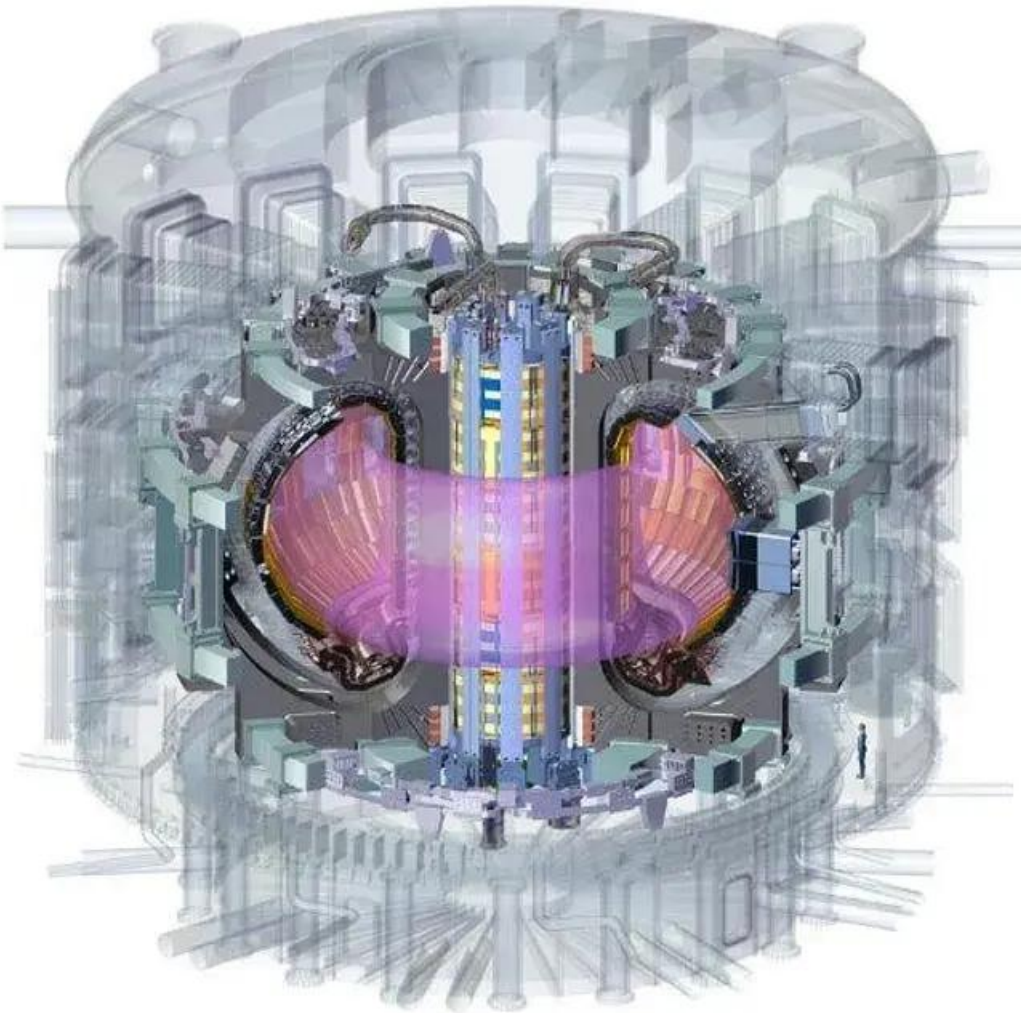
A technician operates within a tokamak at the General Atomics research facility located in San Diego, California. (CREDIT: CC BY-SA 4.0)© The Brighter Side of News

Researchers have taken a crucial step forward in the quest for clean, limitless energy. A team at [General Atomics](#), a research facility operated for the U.S. Department of Energy, has reported a significant breakthrough in nuclear fusion.

Published in the journal [Nature](#), their findings mark an important milestone in advancing fusion technology toward commercial viability.

Addressing the Challenges of Fusion Power

Nuclear fusion, the process that powers stars, is often hailed as the ultimate sustainable energy solution. However, replicating this phenomenon on Earth comes with formidable challenges, primarily involving the creation and maintenance of conditions necessary for [fusion reactions](#). To achieve fusion, scientists must generate and confine plasma—a state of matter consisting of charged particles—at temperatures exceeding hundreds of millions of degrees Celsius. At such extreme conditions, atomic nuclei overcome their natural repulsion, enabling them to fuse and release immense amounts of energy.



The complete ITER device, where a donut-shaped chamber will hold plasma that is superheated until nuclear fusion occurs between hydrogen ions. (CREDIT: ITER)© The Brighter Side of News

Maintaining this high-temperature plasma within a reactor, without it cooling or escaping, is one of the most significant hurdles in realizing practical fusion power.

Tokamak reactors, which are doughnut-shaped devices that use magnetic fields to confine plasma, are a leading technology in nuclear fusion research. A major challenge with [tokamak reactors](#), however, has been managing the density of the plasma, which is limited by what is known as the Greenwald limit.

Understanding the Greenwald Limit

The Greenwald limit, named after physicist Martin Greenwald, defines the maximum density that a plasma can reach while remaining stable within the magnetic confinement system of a tokamak reactor. If plasma density exceeds this threshold, instabilities can arise, disrupting the confinement process and halting fusion. Essentially, the Greenwald limit is a barrier to achieving the conditions necessary for efficient and stable [fusion power](#).

Related Stories

- [Nuclear fusion could power US cities within the next decade](#)
- [A new way to store sustainable energy: 'Information batteries'](#)
- [Genius kid builds a nuclear fusion reactor at home](#)

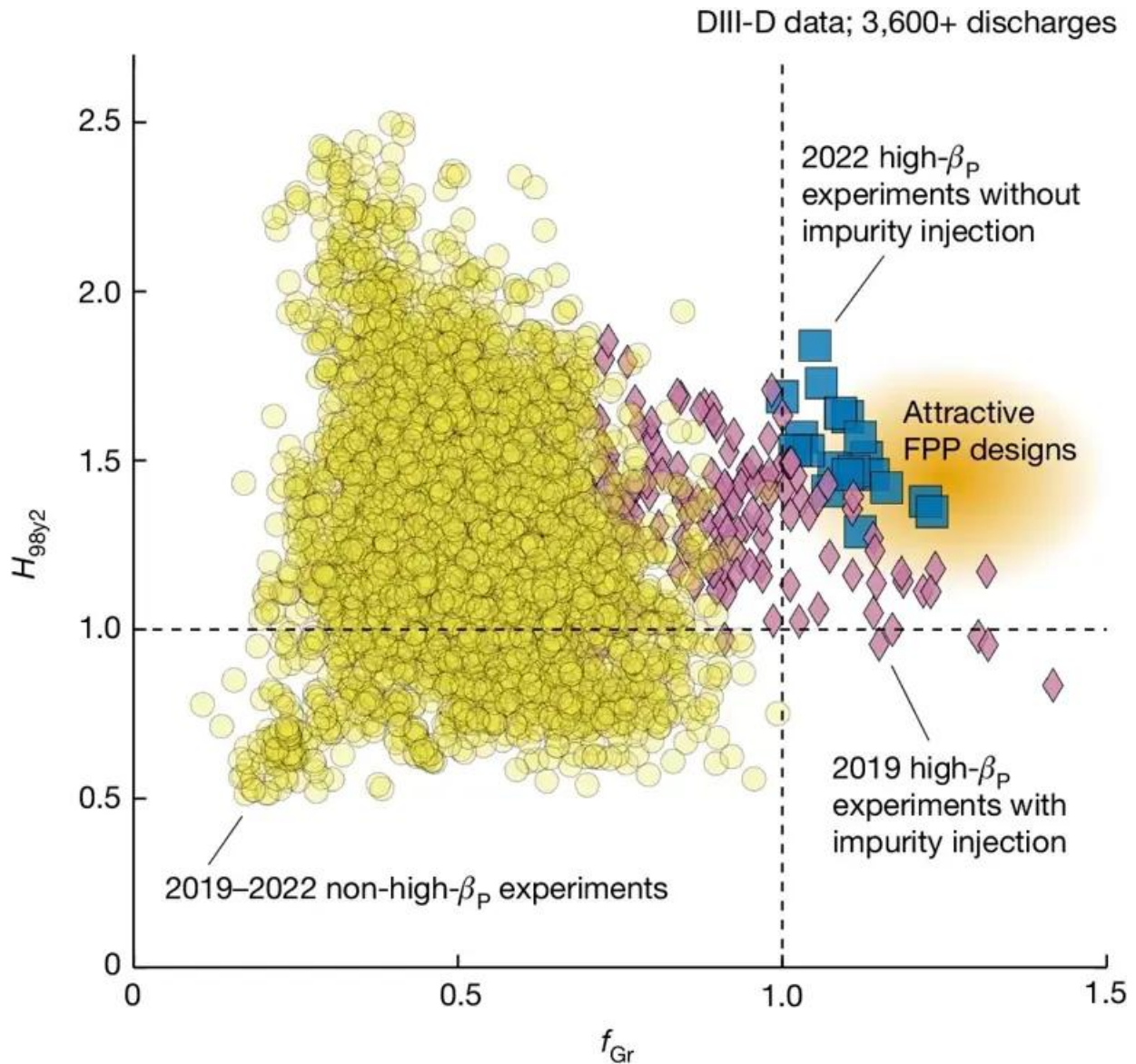
In tokamak reactors, this limit has been a persistent obstacle because, beyond a certain density, the plasma becomes unstable, leading to energy loss or potential damage to the reactor. The inability to exceed the Greenwald limit without significant consequences has posed a challenge for creating a fusion reactor that could operate efficiently and continuously.

Breaking Through the Limit

The General Atomics research team has now managed to overcome this barrier. Their experiment produced stable plasma with a density that is 20% higher than the Greenwald limit. Not only did they achieve this higher density, but they also

maintained a plasma confinement quality that was 50% better than the standard high-confinement mode typically used in [tokamak reactors](#).

This breakthrough is significant because it addresses a major bottleneck for commercial fusion reactors. Many tokamak designs require plasma densities higher than the Greenwald limit to achieve efficient fusion.



Violet diamonds show high- β_p experiments performed in 2019 with impurity injection. Blue squares are the new high- β_p experiments performed in 2022 without impurity injection. Yellow circles represent all other experiments performed in 2019–2022. (CREDIT: Nature)© The Brighter Side of News

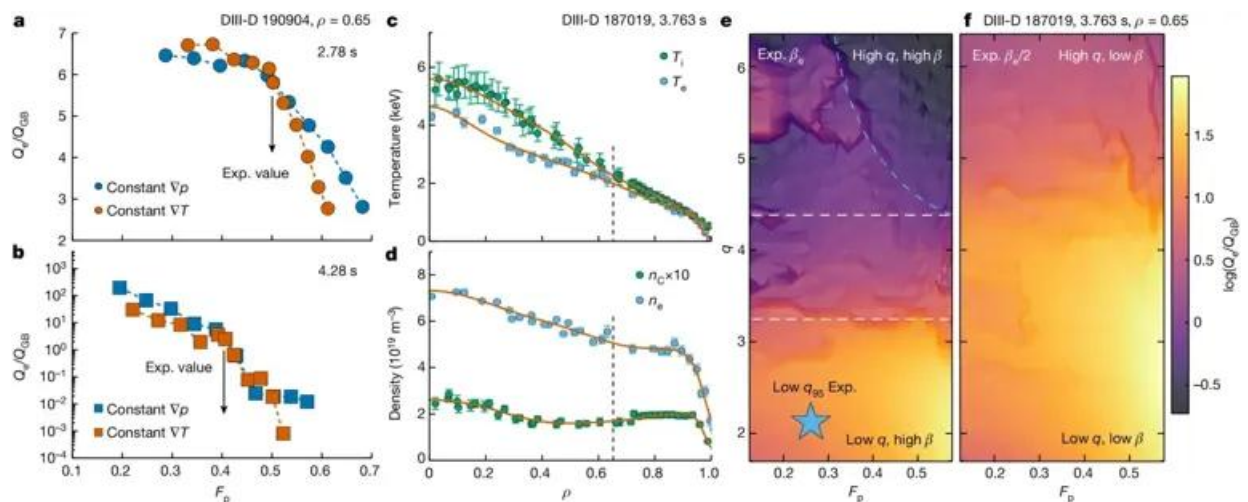
Previous attempts to exceed this limit often resulted in reduced [plasma confinement](#) or complete loss of energy. The success of the General Atomics

team in achieving both high density and strong confinement opens up new possibilities for designing more efficient and reliable fusion reactors.

Managing Plasma Instabilities

Another major hurdle in fusion reactors like tokamaks is controlling the instabilities that can develop within the plasma. These instabilities, if left unchecked, can disrupt the reactor's operations and damage its components. The recent findings from General Atomics not only surpassed the Greenwald limit but also hinted at potential methods for managing these instabilities.

The researchers noted a "synergy" between achieving [high plasma density](#) and maintaining high confinement, which could lead to a more stable state for the plasma. This suggests that it may be possible to achieve conditions where the plasma remains stable even at higher densities, reducing the risk of disruptions that have previously been a major challenge.



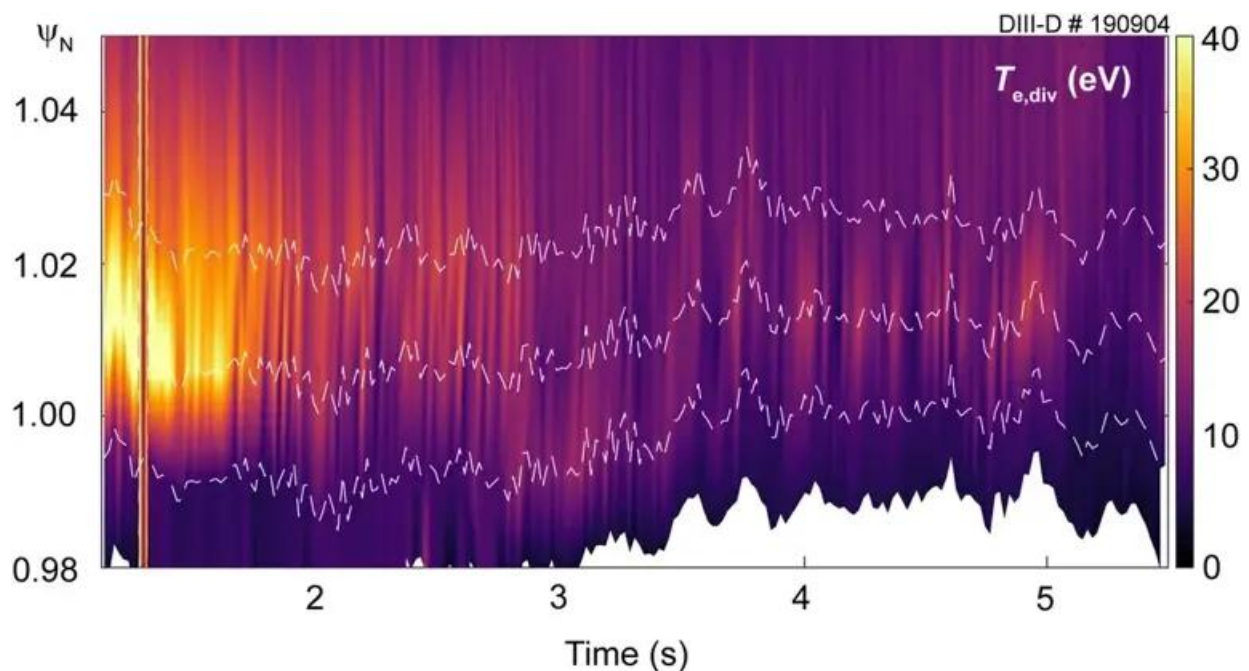
Balancing Temperatures in the Plasma

Fusion reactors also face the challenge of balancing temperatures within the plasma. To initiate fusion, the [core of the plasma](#) must be extremely hot—reaching hundreds of millions of degrees Celsius—while the outer edge, which comes into contact with the reactor walls, needs to be kept much cooler to prevent damage. Achieving and maintaining this balance is crucial for the reactor's efficiency and longevity.

The research from General Atomics provides new insights into how to manage this temperature gradient effectively. Understanding the physics that govern the temperature distribution within the plasma can help in designing reactors that are both compact and efficient. These insights bring researchers closer to solving one of the critical engineering challenges that have held back the development of practical fusion power.

The breakthrough by the General Atomics team represents a significant step towards achieving commercially viable fusion power. By breaking through the Greenwald limit and demonstrating improved plasma confinement, they have unlocked new opportunities for more efficient [fusion energy production](#).

This development could pave the way for the creation of fusion reactors that are capable of operating under conditions necessary for sustained and efficient power generation.



Spatial and temporal evolution of electron temperature at the divertor plates, measured by Langmuir probes. (CREDIT: Nature)© The Brighter Side of News

While there is still much work to be done before fusion power becomes a reality, the progress made by these researchers is a clear indication that we are moving in the right direction.

Achieving stable, high-density plasma in a controlled environment is one of the key milestones on the path to [fusion energy](#), and the recent advances are an encouraging sign that the dream of clean, limitless energy may one day become a reality.

Key Takeaways

- Nuclear fusion is a promising source of clean and sustainable energy, but creating and maintaining the conditions for fusion is extremely challenging.
- Tokamak reactors use [magnetic fields](#) to confine the hot plasma needed for fusion, but plasma density is limited by the Greenwald limit, beyond which instabilities disrupt confinement.
- Researchers at General Atomics have successfully surpassed the Greenwald limit, achieving plasma density 20% higher while maintaining superior confinement.
- This breakthrough addresses a major obstacle for fusion reactors, making it possible to achieve conditions required for efficient fusion.
- The research also provides insights into managing [plasma instabilities](#) and balancing core and edge temperatures, critical for reactor efficiency.
- These advancements mark a significant step towards the realization of commercially viable fusion power.

“Artificial Sun” Shatters Fusion Record With Over 17 Minutes of Plasma

BY CHINESE ACADEMY OF SCIENCES JANUARY 22, 2025



The Experimental Advanced Superconducting Tokamak achieved a remarkable scientific milestone by maintaining steady-state high-confinement plasma operation for an impressive 1,066 seconds. Credit: HFIPS

China’s EAST project has set a new global record by maintaining a high-confinement plasma state for over 17 minutes, paving the way for future clean energy solutions by mimicking the sun’s fusion process.

China’s Experimental Advanced Superconducting Tokamak (EAST), also known as the “artificial sun,” has set a new world record by sustaining high-confinement plasma for an impressive 1,066 seconds. This achievement, reached on January 20, marks a major step forward in the quest to develop fusion power as a clean and limitless energy source.

The 1,066-second milestone represents a significant leap in fusion research. It was accomplished by the Institute of Plasma Physics (ASIPP) at the Hefei Institutes of Physical Science (HFIPS), part of the Chinese Academy of Sciences. This new record greatly exceeds the previous world record of 403 seconds, also set by EAST in 2023.

A Step Towards Unlimited Clean Energy

The ultimate goal of developing an artificial sun is to replicate the nuclear fusion processes that occur in the sun, providing humanity with a limitless and clean energy source, and enabling exploration beyond our solar system.

Scientists worldwide have dedicated over 70 years to this ambitious goal. However, generating electricity from a nuclear fusion device involves overcoming key challenges, including reaching temperatures exceeding 100 million degrees Celsius, maintaining stable long-term operation, and ensuring precise control of the fusion process.



EAST maintained a steady-state high-confinement plasma operation for 1,066 seconds on January 20, 2025. Credit: HFIPS

Record-Setting Performance Enhancements

“A fusion device must achieve stable operation at high efficiency for thousands of seconds to enable the self-sustaining circulation of plasma, which is essential for the continuous power generation of future fusion plants,” said SONG Yuntao, ASIPP director and also vice president of HFIPS. He said that the recent record is monumental, marking a critical step toward realizing a functional fusion reactor.

According to GONG Xianzu, head of the EAST Physics and Experimental Operations division, several systems of the EAST device have been upgraded since the last round of experiments. For example, the heating system, which previously operated at the equivalent power of nearly 70,000 household microwave ovens, has now doubled its power output while maintaining stability and continuity.

Supporting International Fusion Research

Since its inception in 2006, EAST has served as an open testing platform for both Chinese and international scientists to conduct fusion-related experiments and research.

China officially joined the International Thermonuclear Experimental Reactor (ITER) program in 2006 as its seventh member. Under the agreement, China is responsible for approximately 9 percent of the project's construction and operation, with ASIPP serving as the primary institution for the Chinese mission.

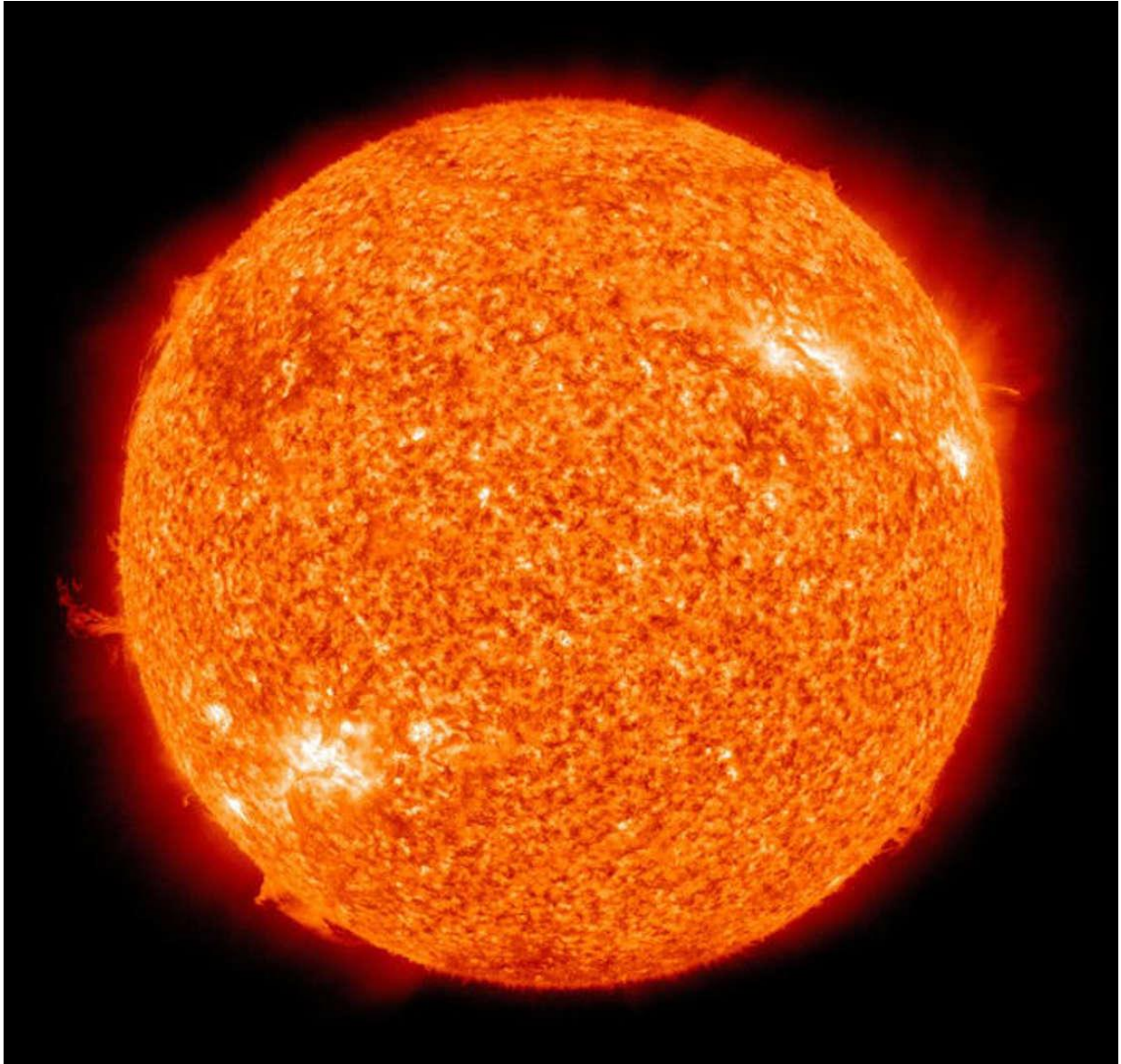
ITER, currently under construction in southern France, is set to become the world's largest magnetic confinement plasma physics experiment and the largest experimental tokamak nuclear fusion reactor upon completion.

In recent years, EAST has consistently achieved groundbreaking advancements in high-confinement mode, a fundamental operational mode for experimental fusion reactors like ITER and the future China Fusion Engineering Test Reactor (CFETR). These accomplishments provide invaluable insights and references for the global development of fusion reactors.

"We hope to expand international collaboration via EAST and bring fusion energy into practical use for humanity," said SONG.

In Hefei, Anhui Province, China, where EAST is located, a new generation of experimental fusion research facilities is currently under construction. These facilities aim to further accelerate the development and application of fusion energy.

[Chinese Academy of Sciences Energy Fusion Energy Fusion Reactor](#)



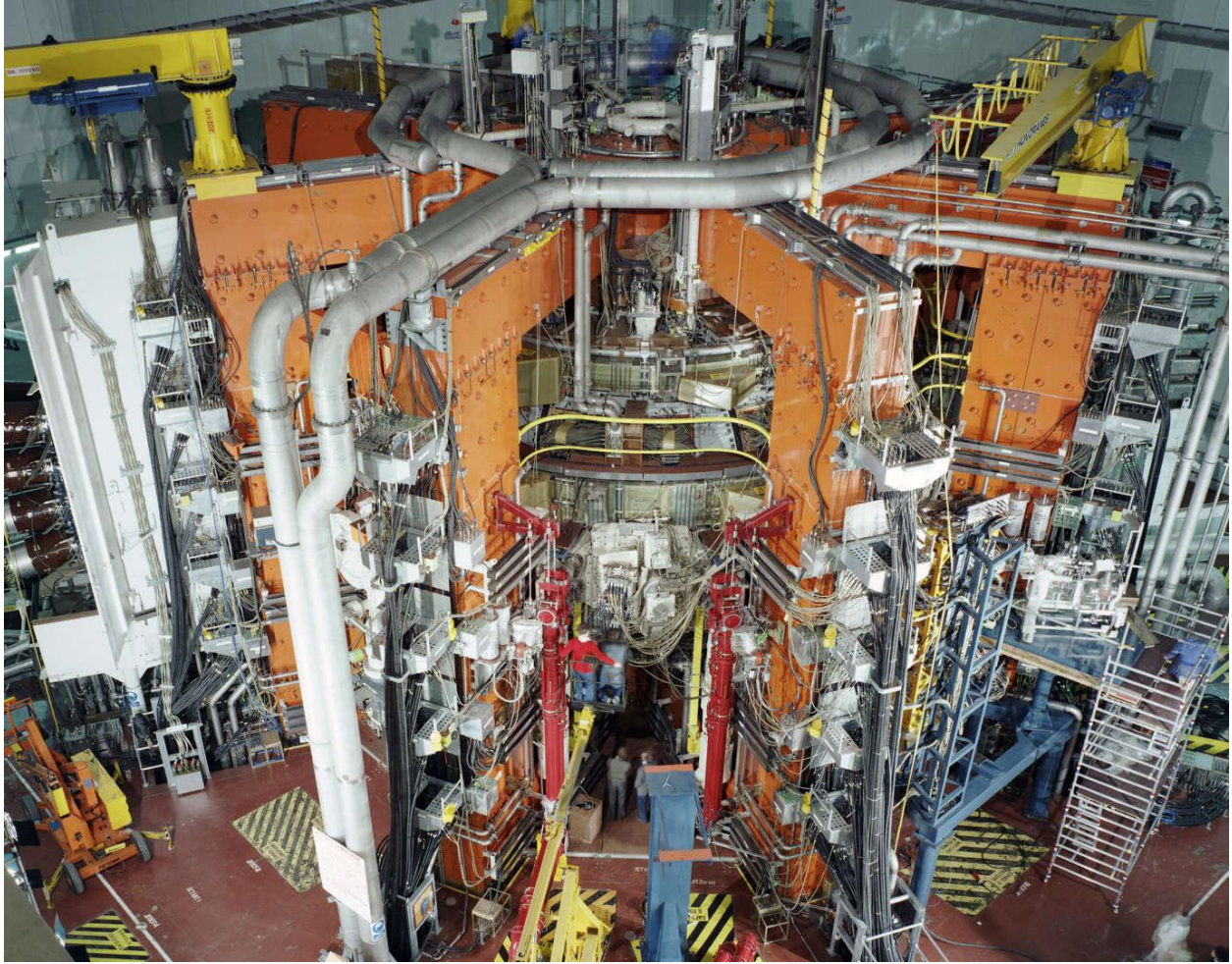
Fusion Mimics the Sun

Fusion energy is nothing short of a marvel, as it seeks to replicate the very process that fuels the sun. At its core, fusion involves the merging of hydrogen nuclei to form helium, a reaction that releases an astonishing amount of energy. Imagine the sun's blazing power harnessed right here on Earth. This process, unlike traditional energy sources, is not merely a chemical reaction but a nuclear one, promising a vast potential for energy generation. The sun's energy has sustained life on our planet for billions of years, and scientists believe that by mimicking this natural phenomenon, humanity could unlock a

nearly limitless energy source. However, achieving this on Earth requires recreating the extreme temperatures and pressures found in the sun's core, which is no small feat.

It Produces Virtually No Carbon Emissions

One of the most appealing aspects of fusion energy is its promise of a clean and sustainable future. Unlike the burning of fossil fuels, which releases harmful greenhouse gases into our atmosphere, fusion energy produces no carbon emissions. This means that it could be a game-changer in the fight against climate change, offering a way to generate electricity without adding to the planet's carbon burden. The lack of emissions from fusion is not just a theoretical benefit but a real-world solution to the pollution problems plaguing our planet. Clean air and a healthier environment could be within reach if fusion energy becomes a reality. The prospect of a pollution-free energy source is tantalizing, especially as the world grapples with the urgent need to reduce carbon footprints.



Recent Breakthroughs Show Promise

In recent years, there have been significant breakthroughs in the pursuit of fusion energy, bringing hope to scientists and environmentalists alike. Notably, experiments at facilities like the National Ignition Facility (NIF) have achieved a "net energy gain," where more energy was produced than consumed during the fusion process. This milestone is akin to finding the key to a long-locked door, suggesting that practical fusion energy is within our grasp. Such achievements have been years, if not decades, in the making, reflecting the dedication and perseverance of researchers in the field. While challenges remain, these breakthroughs demonstrate that the dream of harnessing fusion energy is becoming increasingly tangible. Each success inches us closer to a future where our energy needs are met cleanly and efficiently.



Abundant Fuel Supply

Fusion energy's potential is further bolstered by its virtually limitless fuel supply. The process relies on isotopes such as deuterium, which is abundantly found in seawater, and tritium. This stands in stark contrast to the finite nature of fossil fuel reserves, which are rapidly depleting. The sheer abundance of these isotopes means that, unlike coal or oil, fusion energy could provide a stable energy source for centuries to come. Imagine tapping into the vast oceans for energy—the potential is as vast as the sea itself. This abundance not only promises energy security but also reduces the geopolitical tensions often associated with fossil fuel reserves. With fusion, the worry of running out of fuel becomes a thing of the past, offering stability in an uncertain world.

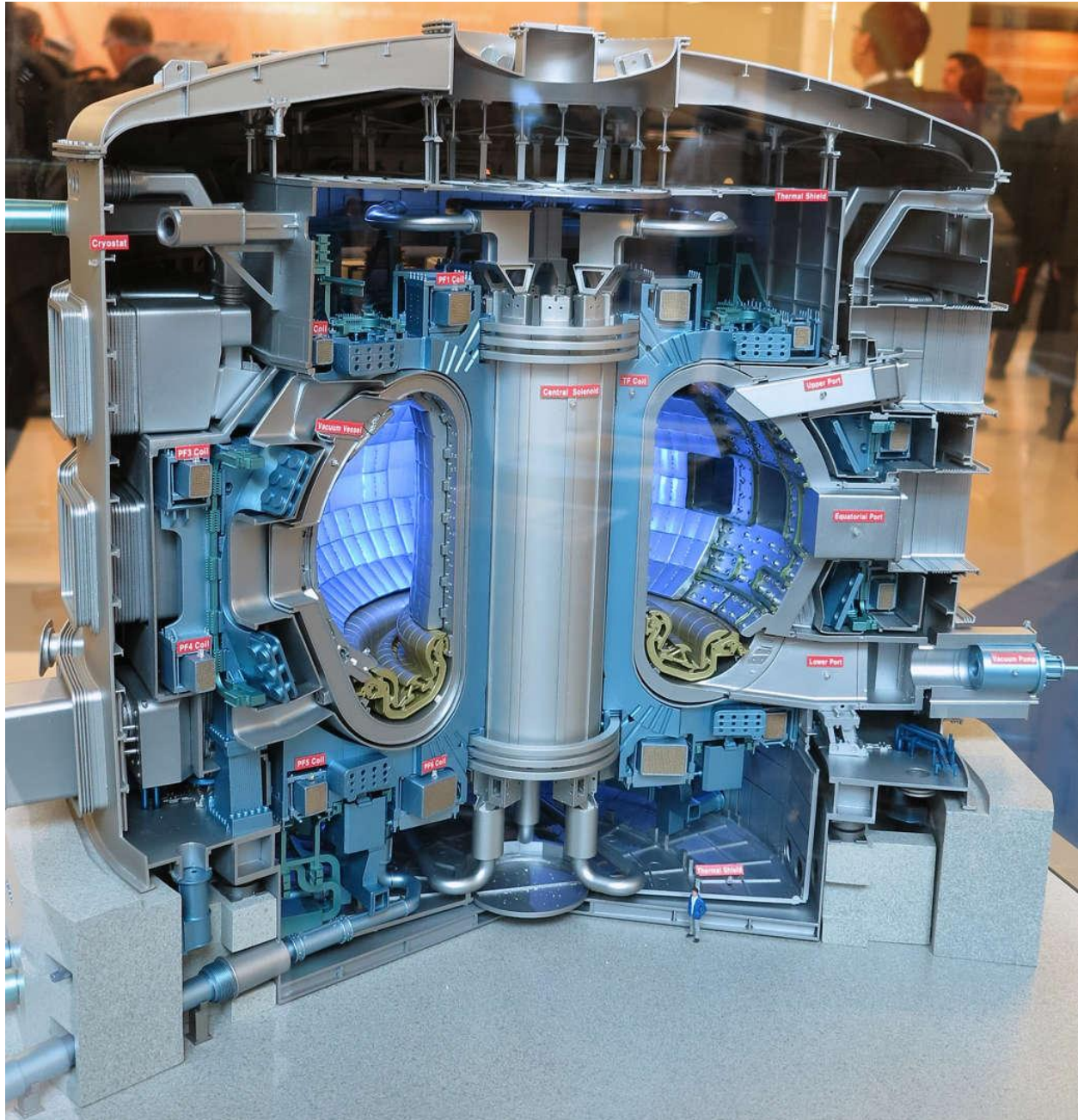
Fusion is Inherently Safe

Safety is a paramount concern when it comes to energy production, and fusion energy stands out in this regard. Unlike nuclear fission, which carries the risk of catastrophic meltdowns, fusion reactions are inherently safe. The process requires extremely precise conditions to sustain itself, meaning that if anything goes wrong, the reaction simply stops. This self-limiting nature of

fusion makes it a much safer alternative to traditional nuclear power. There's no fear of a runaway reaction, and the absence of long-lived radioactive waste further enhances its safety profile. For communities wary of nuclear power's dangers, fusion offers a reassuring alternative, promising energy without the associated risks. The peace of mind that comes with fusion's safety could play a crucial role in its acceptance and adoption.

Cost and Scale are Major Challenges

Despite its many advantages, fusion energy is not without its challenges, particularly when it comes to cost and scale. Building and maintaining fusion reactors require advanced materials and cutting-edge technology, which come with a hefty price tag. The financial investment needed is immense, and this poses a significant barrier to widespread adoption. Furthermore, scaling up these technologies to meet global energy demands is no small task. The economic challenges are as daunting as they are essential to overcome. As promising as fusion is, the path to making it a viable commercial energy source is fraught with financial and technical hurdles. Overcoming these challenges will require collaboration, innovation, and substantial investment from both the public and private sectors.



ITER is a Global Collaborative Effort

At the forefront of the fusion energy quest is the International Thermonuclear Experimental Reactor (ITER), a monumental \$22 billion project involving 35 countries. This global collaboration aims to demonstrate the feasibility of large-scale fusion energy, uniting nations in pursuit of a common goal. ITER represents a beacon of hope, showcasing what can be achieved when the world comes together. The project's scale and ambition are unprecedented,

reflecting the international community's commitment to finding a sustainable energy solution. By pooling resources and expertise, ITER seeks to pave the way for the future of energy. It is a testament to the power of collaboration and the shared desire to create a cleaner, more sustainable world.

Widespread Use is Still Decades Away

While the progress in fusion energy is undeniable, widespread commercial use remains a distant dream. Experts estimate that it may not become a reality until the 2040s or later, as significant hurdles in scalability and efficiency still need to be addressed. The road ahead is long and filled with challenges, requiring continued research, development, and innovation. The timeline reflects the complexity and ambition of the endeavor, reminding us that patience and persistence are key. The dream of fusion energy is not an immediate fix but a long-term solution that holds the promise of transforming our energy landscape. As scientists and engineers work tirelessly to realize this vision, the world watches with anticipation, hopeful for a future where clean, unlimited power is within reach.

World's only floating nuclear plant generates record 1 billion kWh power before refuel



Floating nuclear power plant 'Akademik Lomonosov'© Getty

A floating nuclear power plant has reached a new milestone: it generated one billion kilowatt-hours of energy for the Russian Arctic region over five years as [scientists race to advance](#) the capabilities of nuclear energy,

The Akademik Lomonosov is a 459-foot-long towed platform that can carry two 35-megawatt nuclear reactors. It is a key asset for Russia in the battle for nuclear energy superiority between [East and Western powers](#).

The floating plant has gained significance for Russia after [the worsening condition](#) of one of its nuclear plants caused by the Ukrainian war.

- [Russia 'collapsing' and world must prepare for 'nuclear chaos' warns US chief](#)[Link](#)

- [Vladimir Putin ally says WW3 nearly broke out during Joe Biden's presidency](#)

The plant is meant to provide power for Chukotka, replacing the Bilibino nuclear power plant decommissioned years ago.

The Russian project is the first floating nuclear power plant since the U.S. MH-1A, a much smaller reactor that supplied the Panama Canal with power from 1968-1975.



Floating nuclear power plant 'Akademik Lomonosov'© Getty

Environmentalists have criticized the project as inherently dangerous and threatening the pristine Arctic region.

Russia's state nuclear corporation Rosatom has dismissed those concerns, insisting that the floating nuclear plant is safe to operate.

Rosatom director Alexei Likhachev said his corporation hopes to sell floating reactors to foreign markets. Russian officials have previously mentioned Indonesia and Sudan as potential export customers.

- [Trump's interest in Greenland could be related to its rich mineral deposits](#)

- [Iran to 'dramatically' increase uranium stockpile sparking nuclear WW3 fears](#)
- [Iran to begin enriching uranium with thousands of advanced centrifuges](#)

Countries like Alaska have expressed concern about the Russian ship passing near their country due to the radiation.

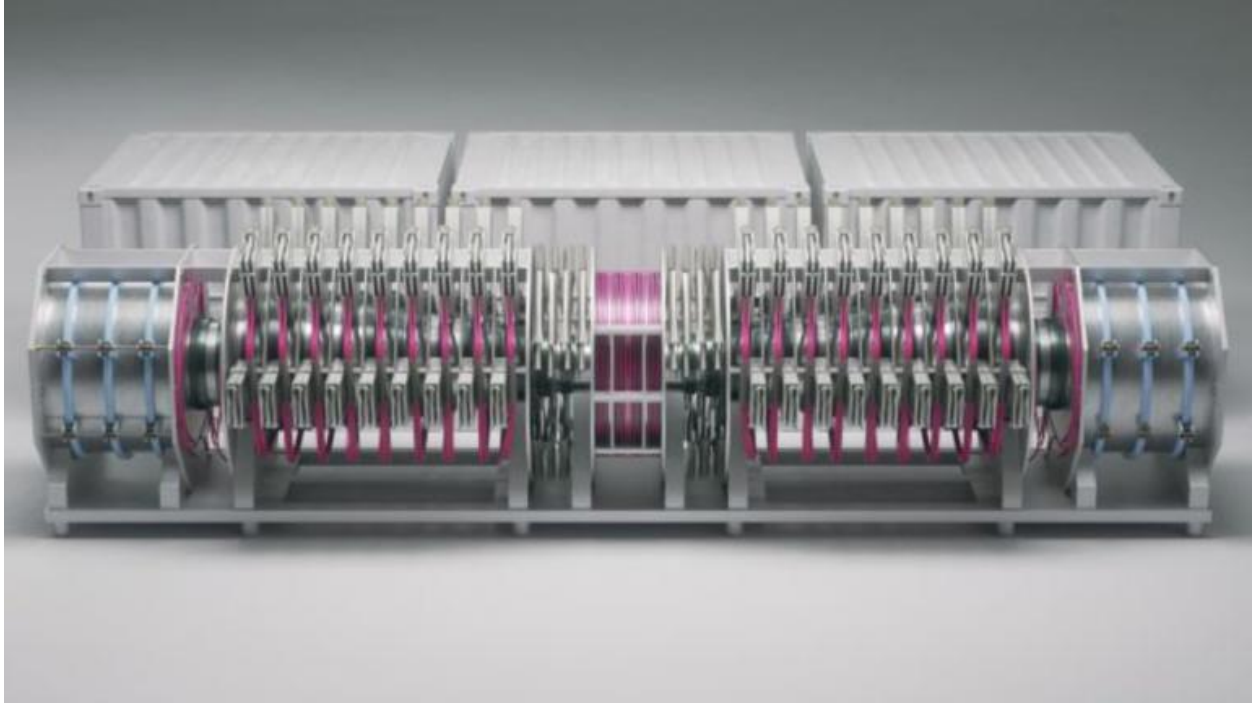
"Radiation effects. Environmental effects - we've been worried about for quite some time in this era of increased shipping, less sea ice," said Austin Ahmasuk, a marine advocate for an Alaskan native non-profit organization.

Vietnam and Russia agreed just a week ago to boost cooperation on nuclear energy, increasing the importance of the energy produced by the Lomonosov.

The demand for nuclear energy has increased as the demand and popularity of A.I. technologies and cryptocurrency increased.

Both require a large amount of energy to process the data, which is why companies like Meta and Google are looking for a nuclear energy provider.

Sam Altman-backed 'world's first' fusion power plant gets funds to power Microsoft



Sam Altman-backed 'world's first' fusion power plant gets funds to power Microsoft

Helion, a leading innovator in fusion energy technology, has announced receiving a fresh \$425 million in funding.

This significant investment will enable Helion to expedite the development of its commercial-scale fusion power plant.

"We will be radically scaling up our manufacturing in the U.S. – enabling us to build capacitors, magnets, and semiconductors much faster than we have been able to before," said David Kirtley, CEO of Helion.

"This accelerates the construction of the world's first fusion power plant and then all our plants to come."

The startup, which is backed by OpenAI boss Sam Altman, Peter Thiel, and Reid Hoffman, aims to deliver electricity to Microsoft by 2028.

Helion adopts unique approach

While there are many fusion startups, Helion distinguishes itself through its unique approach to fusion energy. It employs a “field-reversed configuration” reactor.

This technology diverges from the more conventional magnetic confinement and [inertial confinement](#) methods. Instead, Helion’s reactor utilizes a series of magnetic fields to control and compress plasma within a specifically designed chamber.

The process begins with the injection of deuterium and helium-3 gas into each end of the reactor. This gas is then heated to form a plasma, which is subsequently shaped and accelerated by magnetic fields to speeds exceeding 1 million miles per hour.

“Deuterium and helium-3 fuel is heated to plasma conditions. Magnets confine the plasma in a Field Reversed Configuration (FRC),” explained the fusion firm.

These plasma formations collide within the central chamber of the reactor.

“When the FRCs collide in the center of the system, they are further compressed by a powerful magnetic field until they reach fusion temperatures greater than 100 million degrees Celsius (9keV),” [added](#) the company.

Direct energy conversion and Polaris prototype

A key advantage of [Helion](#)’s technology lies in its direct energy conversion. The energy released from the fusion reactions creates a surge in magnetic force, which is captured and converted directly into electricity.

“As the plasma expands, it pushes back on the magnetic field from the machine’s magnets. By Faraday’s Law, the change in field induces current, which is directly recaptured as electricity, allowing Helion’s fusion generator to skip the steam cycle,” highlighted the startup.

Helion's latest prototype, Polaris, is now operational in Everett, Washington. The fusion firm anticipates that Polaris will be the first fusion reactor to generate electricity.

To achieve its ambitious goal of supplying power to Microsoft by 2028, Helion is focused on expanding its manufacturing capabilities and building the necessary infrastructure for a commercial-scale power plant.

Competition in fusion energy

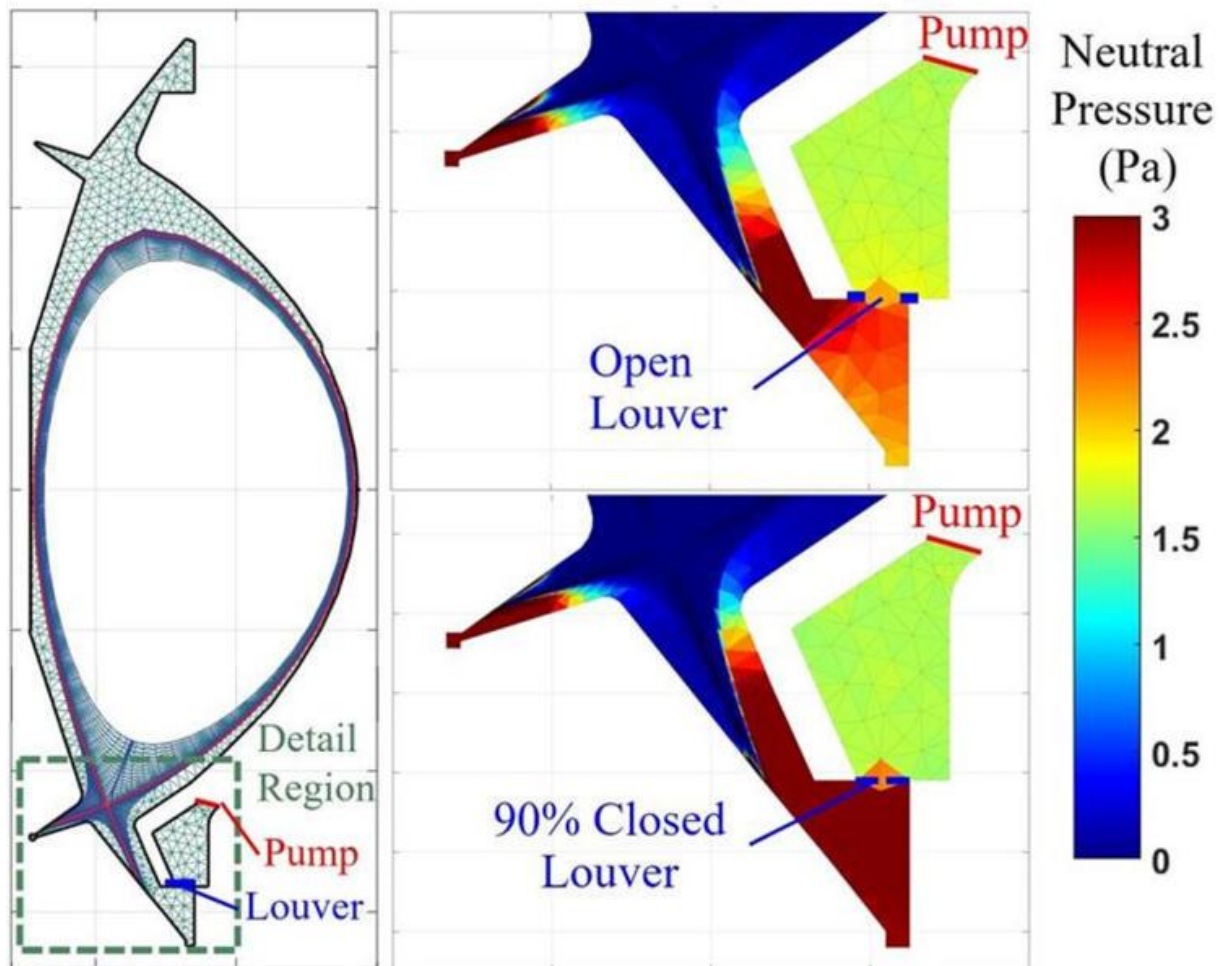
Notably, several startups across the world have been working aggressively to develop commercial fusion reactors to generate electricity.

Recently, US-based startup Commonwealth Fusion Systems (CFS) announced that it is set to build the [world's first](#) grid-scale commercial fusion power plant.

According to CFS, its fusion plant will be built at the James River Industrial Park in Chesterfield County, Virginia, and become operational in the early 2030s.

Meanwhile, another fusion power startup, Focused Energy, has acquired two powerful lasers to trigger a fusion reaction more efficiently.

Controlling plasma heat in a fusion energy power plant: 'Louvers' on fusion device should exhaust gases as hot as a star



Left: geometry of the SPARC tokamak showing the pump volume and the "louver" actuator that restricts gas flow between the plasma and pumping chambers. Right: neutral gas pressure increases strongly with the louver closed. Credit: Adapted from Park, J.-S., et al. "Full time-dependent SOLPS-ITER simulation of the SPARC tokamak: Actuator design for particle and divertor condition control," Nuclear Fusion 64, 076036 (2024). Creative Commons Attribution 4.0 license).

Commonwealth Fusion Systems (CFS) is developing a [tokamak](#) device called SPARC. The company aims to demonstrate the critical fusion energy milestone of producing more output power than input power for the first time in a device that can scale up to commercial power plant size. However, this achievement is only possible if the plasma doesn't melt the device.

Researchers from CFS and Oak Ridge National Laboratory (ORNL) have collaborated on fusion boundary research through a series of projects, including ORNL Strategic Partnership Projects and Laboratory Directed Research and Development projects, work under the Innovation Network for Fusion Energy (INFUSE), and other work in partnership with General Atomics.

Throughout this collaboration, ORNL has developed simulation capabilities required to address critical and time-sensitive design issues for the SPARC tokamak.

The study, [appearing](#) in *Nuclear Fusion*, evaluated actuator configurations, in particular those used to control neutral gas flowing in and out of the tokamak.

A power-producing fusion plasma must reach a temperature at its center hotter than the core of the sun. At the same time, it must maintain a temperature at the plasma edge that is cool enough to avoid vaporizing the fusion device.

New studies have found that using louvers at the bottom of the fusion device, like those found on the air ducts of a home, create local conditions that can reduce the temperature of the edge plasma. Specifically, the louvers allow the hot plasma to "detach" from the walls of the device, spreading out the heat.

To predict the actuators' ability to control the plasma, ORNL developed new methods to run a major simulation code, SOLPS-ITER, in a dynamic, time-dependent manner, focused on the actuator design.

The SOLPS-ITER code models plasma and neutral transport in the boundary region of fusion devices and has been used to design plasma-facing components for many tokamaks, including the multinational ITER device under construction in France.

This new dynamic simulation capability goes beyond standard steady-state models and was developed in a staged manner, first considering only plasma transport for predictive control, then the response of neutral particles to louver actuators, then finally a fully coupled dynamic model.

The CFS team then used this information to zero in on the simplest and least expensive actuator and diagnostics options from a large number of candidates. This work enables fusion energy scientists to better control tokamak devices.

The results of this study show a new path for handling this extreme heat, bringing researchers one step closer to a fusion energy source. The study used a new simulation capability that advances work on whole-device modeling and helps inform researchers about the systems that will control the SPARC plasma.

In addition to the SPARC tokamak, CFS is planning its successor, the ARC power plant, to put power on the electric grid.

More information: Jeremy D. Lore et al, Evaluation of SPARC divertor conditions in H-mode operation using SOLPS-ITER, *Nuclear Fusion* (2024). [DOI: 10.1088/1741-4326/ad85f3](https://doi.org/10.1088/1741-4326/ad85f3)

Provided by US Department of Energy



This is the first silent home wind turbine that destroys solar panels – 1500 kWh of free electricity

[January 31, 2025](#)



RenewPower.com

[This country, covered with solar panels. 200,000 with unexpected result](#)
[America buries hydrogen after finding something better: It's under these green lakes](#)
[More than 20 million tons: China just found "something" hidden underneath Tibet](#)

Wind power is gradually rising to the challenge, and in the residential market, it is as popular as solar power. Meet the Liam F1 Mini Urban Wind Turbine by Archimedes – a miniature wind turbine specially developed for city use.

This small and revolutionary product delivers energy to home roofs and **generates up to 1500 kWh of free electricity** per year — and it is silent. The Liam F1 is quickly proving to be a strong contender for solar energy solutions and a worthy contender for solar panels for consumers who are concerned about sustainability and the environment.

A quiet revolution: why silence matters in urban energy solutions

The Liam F1 Mini Urban Wind Turbine is also characterized by one of the major benefits of wind energy – it is almost noiseless. Cities are often sensitive to noise, and even though wind turbines are beneficial and clean, their noise is also a problem for the people living nearby.

The Liam F1 Mini is virtually noiseless because of its conical design, and it can fit in areas with high population density. This lets the homeowners get the wind energy they need **without impacting their environment, making it different from the standard wind turbines**. The Liam F1 is designed for urban and suburban areas where noise is a major concern when installing renewable energy generators.

The design of the Liam F1 Mini is best suited for cities because turbulence is a characteristic of the wind within city limits. In such conditions, conventional turbines are ineffective; on the contrary, the Liam F1 is designed to perform well.

It actually has a helix-like structure, so it can self-adjust to face the wind in the same way that a weather vane moves. These features guarantee optimal performance and power generation irrespective of fluctuating, oscillating wind conditions.

With an efficiency in capturing wind energy, the **Liam F1 Mini produces approximately 1500 kilowatt hours per year** with a low wind velocity of 5 m/s. This is a huge output for urban homes as it supplies clean energy that can be utilized instead of the grid.

Compact and versatile: adaptable for every home environment

The Liam F1 Mini's cutout is a mere 1.5 m in diameter, and the structure is compact and lightweight; therefore, it can be mounted on almost any roof without requiring massive pole-like supports.

The size of this system also makes it easy to integrate into homes, and its design can easily fit any residential environment; homeowners can even opt for custom colors to best suit their exterior. The Mini version is **slightly smaller and measures 0.75 meters in diameter**, allowing more installation options, particularly in houses with small roofs.

This compact design does not come at the cost of power; in fact, it allows homeowners to incorporate renewable energy into their homes where they might not have been able to otherwise because of the size of the wind turbines.

The Liam F1 Mini Urban Wind Turbine can be noted not only in terms of energy produced but also in the aspect of cost and simplicity of service. It has a high energy output, which makes it possible to recoup costs in a short period when government incentives for renewable power generation are available.

Moreover, this wind turbine can be combined with solar power to form a combined system that can receive the best of wind and solar energy. Together, they provide nearly a continuous power supply to cover energy requirements all through the day.

Owners of the Liam F1 not only save their money on energy but also help to **lessen the amount of CO2 emissions in their households.**

Shaping the future of sustainable home energy solutions

The Liam F1 Mini Urban Wind Turbine has created a niche in the renewable energy market by combating the problems of energy generation in urban areas. It is ideal for homeowners searching for sustainable power solutions since it is quiet, performs optimally in urban areas, is compact, and economically feasible.

That is why, with the growing number of cities and individual homeowners choosing renewable sources, inventions like the Liam F1 will soon turn roofs into effective power plants.

The Liam F1 opens the way to cleaner and more accessible energy for all by providing an option or at least a supplement to solar power as a renewable energy source for our cities and setting the new standard in urban renewable energy.

Flower Turbines and Aeromine Technologies



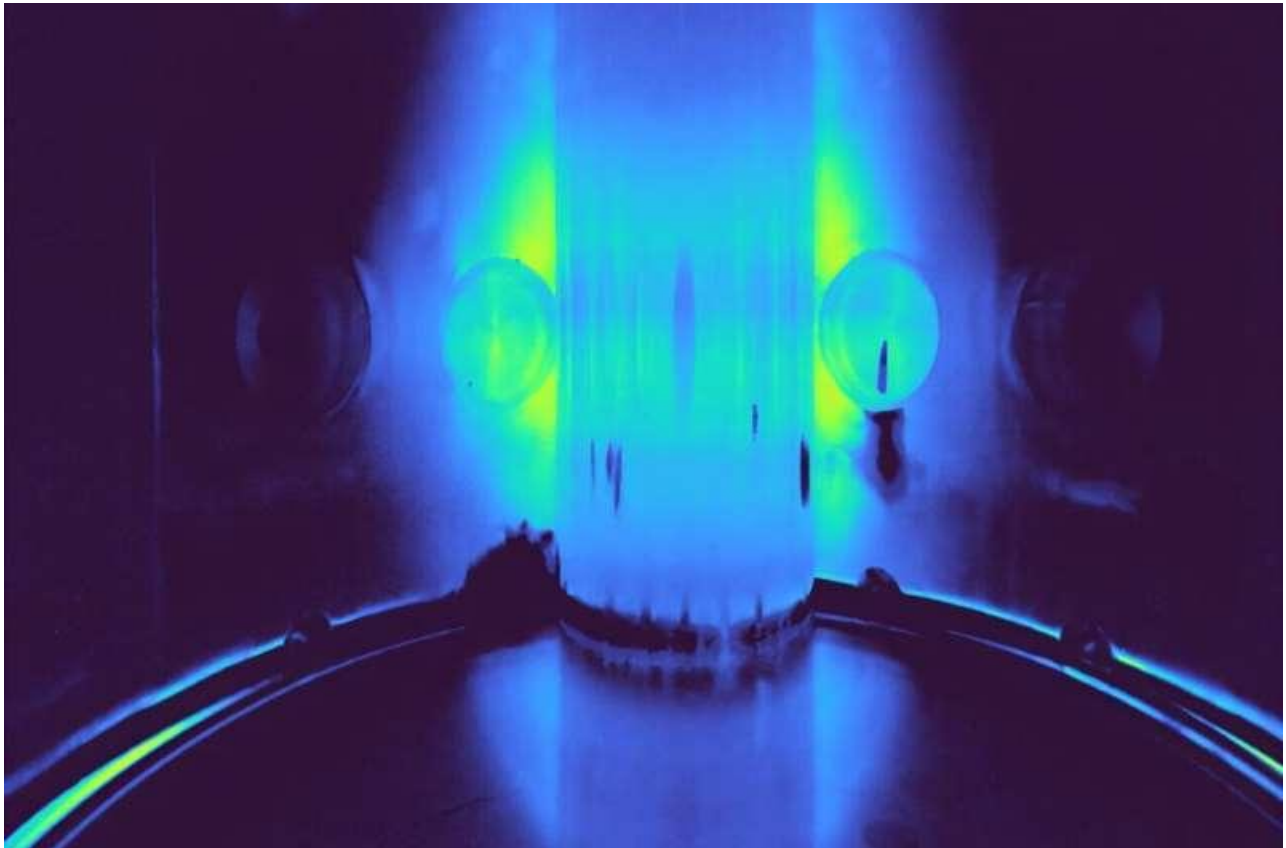
[Revolutionary Noiseless Turbines Transforming Urban Energy](#)

Welcome to the world of Flower Turbines. The main issue with wind energy is the fact that it takes up a pretty substantial amount of space. Having a massive spinning blade is dangerous in urban areas, aesthetically unappealing, and needs a ton of space to operate. Flower Turbines solves these issues with their patented vertical wind turbines. They are designed in a way where they can be placed right next to each other and still be efficient and safely placed all over someone's house and most public places. This introduces a plethora of new opportunities to introduce wind-based power production into various types of existing infrastructure. And they also complement solar, which means these aren't necessarily a direct competitor.

JANUARY 21, 2025

SMART: One step closer to nuclear fusion with its first plasma

by [University of Seville](#)



First tokamak plasma at the Small Aspect Ratio Tokamak—SMART—recorded with a fast-framing camera in the visible spectral range. Credit: University of Seville

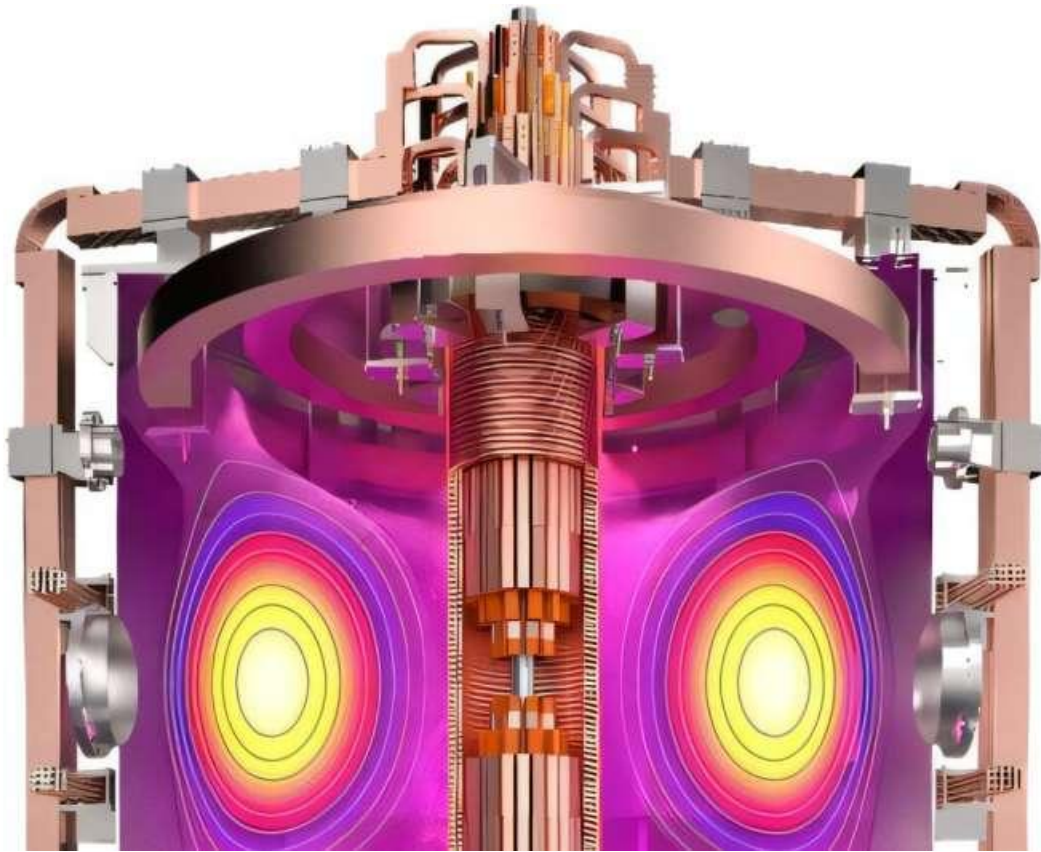
In a pioneering approach to achieve fusion energy, the SMART device has successfully generated its first tokamak plasma. This step brings the international fusion community closer to achieving sustainable, clean, and virtually limitless energy through controlled fusion reactions.

The work is [published](#) in the journal *Nuclear Fusion*.

The SMART tokamak, a state-of-the-art experimental fusion device designed, constructed and operated by the Plasma Science and Fusion Technology Laboratory of the University of Seville, is a unique spherical tokamak due to its flexible shaping capabilities. SMART has been designed to demonstrate the unique physics and engineering properties of Negative Triangularity shaped plasmas towards compact fusion power plants based on Spherical Tokamaks.

Prof. Manuel García Muñoz, Principal Investigator of the SMART tokamak, stated, "This is an important achievement for the entire team as we are now entering the operational phase of SMART. The SMART approach is a potential game changer with attractive fusion performance and power handling for future compact fusion reactors. We have exciting times ahead."

Prof. Eleonora Viezzer, co-PI of the SMART project, adds, "We were all very excited to see the first magnetically confined plasma and are looking forward to exploiting the capabilities of the SMART device together with the international scientific community. SMART has awoken great interest worldwide."



Render of the SMART tokamak with a Negative Triangularity fusion plasma inside. Credit: University of Seville

When negative becomes positive and compact

The triangularity describes the shape of the plasma. Most tokamaks operate with positive triangularity, meaning that the plasma shape looks like a D. When the D is mirrored, the plasma has negative triangularity.

Negative triangularity plasma shapes feature enhanced performance as they suppress instabilities that expel particles and energy from the plasma, preventing severe damage to the tokamak wall.

Besides offering high fusion performance, negative triangularity also features attractive power handling solutions, given that it covers a larger divertor area for distributing the heat exhaust. This also facilitates the [engineering design](#) for future compact fusion power plants.

Fusion2Grid aimed at developing the foundation for the most compact fusion power plant

SMART is the first step in the Fusion2Grid strategy led by the PSFT team and, in collaboration with the international fusion community, is aimed at the most compact and most efficient magnetically confined fusion power plant based on Negative Triangularity shaped Spherical Tokamaks.

SMART will be the first compact spherical [tokamak](#) operating at fusion temperatures with negative triangularity shaped plasmas.

The objective of SMART is to provide the physics and engineering basis for the most compact design of a fusion power plant based on high-field Spherical Tokamaks combined with Negative Triangularity. The solenoid-driven [plasma](#) represents a major achievement in the timeline of getting SMART online and advancing towards the most compact fusion device.

More information: D.J. Cruz-Zabala et al, Performance prediction applying different reduced turbulence models to the SMART tokamak, *Nuclear Fusion* (2024). [DOI: 10.1088/1741-4326/ad8a70](#)

Provided by [University of Seville](#)

US firm's nuclear fusion tech hits stable plasma milestone without magnetic fields

Zap's experiments on 433 plasma shots show nearly isotropic neutron emissions, confirming the stability and scalability of its fusion process.

Updated: Feb 04, 2025 09:15 AM EST

AUS nuclear fusion startup claims a new study confirms its technology produces stable thermal plasmas—an essential step toward scalable energy gains.

Researchers measured neutron energy isotropy from Zap Energy's Fusion Z-pinch Experiment (FuZE) device, showing uniform neutron emissions, a key indicator of a well-behaved plasma.

According to researchers, the findings provide the strongest validation yet that Zap's sheared-flow-stabilized Z pinch approach is on track for higher fusion yields. The breakthrough strengthens confidence in advancing to the FuZE-Q device, bringing Zap closer to practical fusion energy.

"Essentially, this measurement indicates that the plasma is in a thermodynamic equilibrium. That means we can double the size of the plasma and expect the same sort of equilibrium to exist," said Uri Shumlak, Zap's Chief Scientist and Co-Founder, in a blog post.

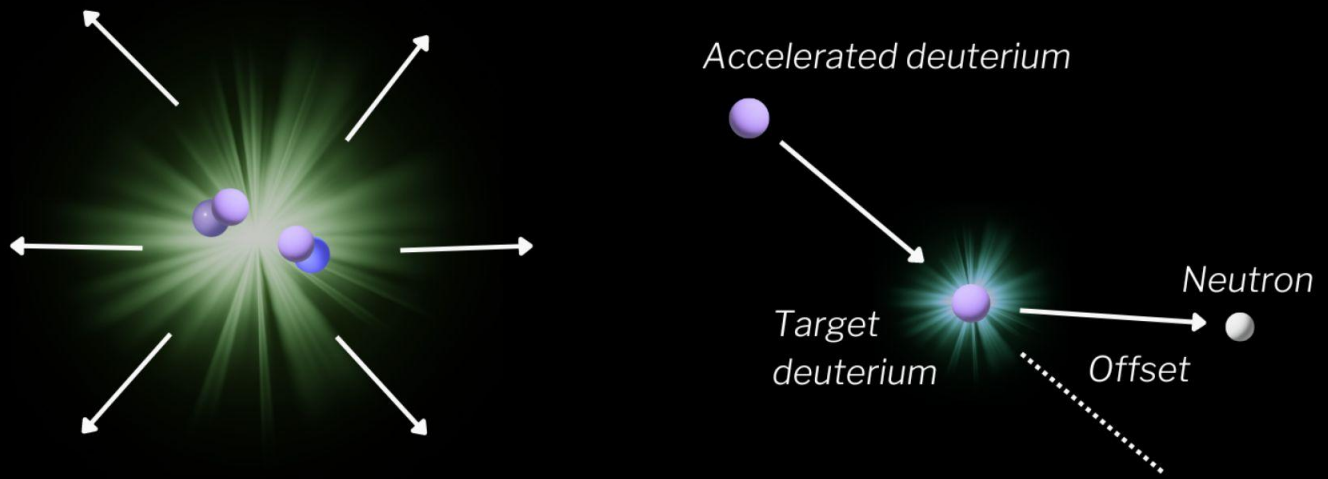
In October 2024, the Seattle-based Zap [unveiled](#) Century, its first fully integrated prototype demonstrating key technologies for a fusion power plant.

Fusion stability confirmed

Zap's fusion process relies on thermal fusion, where hydrogen nuclei fuse into helium under extreme heat and pressure, releasing high-energy neutrons that carry 80 percent of the reaction's energy.

The more neutrons produced, the greater the energy potential. However, not all fusion reactions are ideal. Beam-target fusion, which occurs when fast-moving hydrogen nuclei collide with stationary ones, suggests plasma instability and does not scale effectively for net energy production.

Thermal fusion produces neutrons with isotropic energy—uniform in all directions—while beam-target fusion results in anisotropic emissions, where neutron energies vary by direction.



Thermal or thermonuclear neutrons emit with the same energy in all directions and indicate fusion can scale.

Beam-target neutrons emit with higher energy in certain directions and indicate fusion can't scale.

Fusion can emit neutrons as the result of either thermal or beam-target physics. Measuring neutron isotropy is a straightforward way to determine how much of the fusion in Zap's FuZE device is truly thermal. If neutron emissions were primarily anisotropic, it would indicate that the system is not scalable for net energy gain.

To test this, Zap scientists conducted a series of experiments using neutron detectors placed around the FuZE device. Analyzing 433 plasma shots under identical conditions, they found the neutron emissions to be nearly completely isotropic.

According to researchers, the findings confirm that Zap's fusion process remains stable and scalable, reinforcing confidence in its approach to achieving practical fusion energy.

Scalable fusion progress

Neutron isotropy is not just a key physics benchmark—it also carries historical significance for Zap's fusion approach. The Z pinch, one of the oldest fusion concepts, dates back to the 1950s with the UK's Zero Energy Thermonuclear Assembly (ZETA) experiment.

Scientists initially believed they had achieved fusion by using magnetic fields to compress plasma. However, their success was short-lived, as the fusion observed came primarily from beam-target interactions caused by magnetic instabilities. This meant ZETA could never achieve net energy gain, turning an anticipated breakthrough into a major disappointment.

This issue has long plagued pinch-based fusion approaches, and even today, all fusion technologies risk mistaking beam-target neutrons for true thermal fusion. For example, the dense plasma focus (DPF) device, while effective at generating neutrons, is largely dismissed as a viable fusion power source due to its reliance on beam-target reactions.

After first measuring thermal [fusion](#) in 2018, [Zap](#) has now confirmed its findings with higher sensitivity and at higher energies. These latest results validate that sheared flows can delay instabilities that previously doomed Z pinches, making scalable, magnet-free fusion a promising reality.

“The paper represents a major physics consideration. This is why we put so much effort into making these precise measurements,” said Shumlak, in a [blog post](#).

Zap’s team is now testing neutron isotropy at higher energies on the FuZE-Q device, with promising early results. Ongoing measurements will ensure beam-target fusion isn’t impacting yields.

The study also found neutron isotropy decreased near the end of each shot, likely indicating pinch instability before fusion stops. Understanding this phase could help prevent instabilities, extend plasma duration, and improve performance, bringing Zap closer to sustained, high-yield fusion energy, according to the firm.

Georgia Power plans additional nuclear capacity

Tuesday, 4 February 2025

Georgia Power has filed its 2025 Integrated Resource Plan, saying it has proposed power uprates at four units at its Hatch and Vogtle nuclear power plants and that additional nuclear power capacity will be needed over the long-term.



The four-unit Vogtle plant (Image: Georgia Power)

The 2025 Integrated Resource Plan (IRP) - filed on 31 January with the Georgia Public Service Commission (PSC) - details the company's plan to meet the energy needs of customers and support the state's expected continued extraordinary growth. In the plan, the company has proposed necessary investments in its generation fleet and transmission system to help ensure Georgia Power can continue to provide its customers with "the reliability and resiliency they deserve and expect, as well as demand-side and customer programmes".

Over the next six years, Georgia Power projects about 8200 MW of electrical load growth – an increase of more than 2200 MWe in peak demand by the end of 2030 when compared to projections in the 2023 IRP Update, which was approved by the Georgia PSC in April 2024.

The company said it has "identified opportunities to upgrade several of its existing nuclear units to provide additional capacity. This additional baseload energy can aid in meeting growing capacity needs without the need for incremental transmission system investment".

Georgia Power - a subsidiary of Southern Company - is proposing extended power uprates (EPU) upgrades at units 1 and 2 of its Vogtle nuclear power plant and units 1 and 2 at its Hatch plant. Between 2028 and 2034, it plans to add a total of an additional 112 MWe of capacity at the four units: 27 MWe each at Vogtle 1 and 2; 30 MWe at Hatch 1 and 28 MWe at Hatch.

Extended power uprates involve significant modifications to major plant equipment to increase the thermal output of the reactor. "The EPU process includes an extensive analysis of plant systems and components to verify the capability and identify needed modifications to support the power upgrade at each facility," Georgia Power said.

For the Hatch units, the company is also planning to complete a necessary upgrade to boiler water reactors (BWRs) called the 'Maximum Extended Load Line Limit (MELLA+)' enhancement. This increases capacity by allowing for higher thermal power without increasing core flow to support EPU for BWRs. In addition to the upgrades described above, the company is considering an option for Vogtle units 1 and 2 that would transition the outage window to a 24-month cycle. This upgrade would extend unit runtimes and decrease the number of refueling outages across the fleet.

Georgia Power said it is working with the US Nuclear Regulatory Commission (NRC) as a part of the required review and licensing process. The NRC will review the licence amendment request that contains the detailed analysis to support the power upgrades and concur with approval to allow the upgrade of each facility.

Nuclear new build possible

"The company believes that additional nuclear power will be needed over the long-term to reliably and economically serve the energy needs of its customers," Georgia Power said. "Similarly, nuclear power provides a long-term pathway to reduce carbon emissions and mitigate the cost pressures that potential future environmental regulations could impose on the existing fossil-fired fleet and future new fossil resources."

The company said it develops "multiple views of future cost and performance of generating technologies, multiple views of future electricity consumption, and multiple views of the future price of fuels to support expansion planning for future years of need. Accordingly, B2025 scenarios select nuclear generation in six of nine scenarios over the 20-year planning horizon and as early as 2037."

However, it says: "Even with new nuclear generation's numerous benefits, undertaking the construction of new nuclear generation carries substantial risks for all stakeholders involved. Before proposing additional new nuclear generation, the company believes that solutions must be developed to adequately balance and mitigate risks to stakeholders."

It adds that "preserving viable new nuclear generation options for the benefit of customers is a priority" for the company. Accordingly, it continues to perform in-depth assessments of potential project sites, evaluate available and emerging technologies, and engage with stakeholders in developing improved methods to deploy new nuclear generation projects. "Over the long-term, with adequate additional risk mitigations and leveraging the experience gained with Vogtle units 3-4, the company believes customers would benefit from additional new nuclear in the future."

"At Georgia Power, our vision extends far beyond today - we plan for tomorrow, the next ten years and decades to come," said Kim Greene, chairman, president and CEO of Georgia Power. "As Georgia continues to grow, this state is well-positioned for the future thanks to proactive planning, policies, and processes like the Integrated Resource Plan. The 2025 IRP provides a comprehensive plan to support Georgia's

continued economic growth and serve Georgians with clean, safe, reliable and affordable energy well into the future."

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How to make small modular reactors more cost-effective

Youyeon Choi is leaning on her work experience in South Korea — a leading nation in nuclear energy — and her love of multi-physics modeling as she pursues her doctoral research.

Poornima Apte | Department of Nuclear Science and Engineering

**Publication Date:
January 24, 2025**



Caption:

“I really do believe nuclear energy is going to be a leading carbon-free energy. It’s very important for our collective futures,” says Youyeon Choi, a doctoral student in MIT’s Department of Nuclear Science and Engineering.

Credits:

Photo: Gretchen Ertl

When Youyeon Choi was in high school, she discovered she really liked “thinking in geometry.” The shapes, the dimensions ... she was into all of it. Today, geometry plays a prominent role in her doctoral work under the guidance of Professor Koroush Shirvan, as she explores ways to increase the competitiveness of small modular reactors (SMRs).

Central to the thesis is metallic nuclear fuel in a helical cruciform shape, which improves surface area and lowers heat flux as compared to the traditional cylindrical equivalent.

A childhood in a prominent nuclear energy country

Her passion for geometry notwithstanding, Choi admits she was not “really into studying” in middle school. But that changed when she started excelling in technical subjects in her high school years. And because it was the natural sciences that first caught Choi’s eye, she assumed she would major in the subject when she went to university.

This focus, too, would change. Growing up in Seoul, Choi was becoming increasingly aware of the critical role nuclear energy played in meeting her native country’s energy needs. Twenty-six reactors provide nearly a third of South Korea’s electricity, according to the [World Nuclear Association](#). The country is also one of the world’s most prominent nuclear energy entities.

In such an ecosystem, Choi understood the stakes at play, especially with electricity-guzzling technologies such as AI and electric vehicles on the rise. Her father also discussed energy-related topics with Choi when she was in high school. Being soaked in that atmosphere eventually led Choi to nuclear engineering.

Youyeon Choi: Making small modular reactors more cost-effective

Early work in South Korea

Excelling in high school math and science, Choi was a shoo-in for college at Seoul National University. Initially intent on studying nuclear fusion, Choi

switched to fission because she saw that the path to fusion was more convoluted and was still in the early stages of exploration.

Choi went on to complete her bachelor's and master's degrees in nuclear engineering from the university. As part of her master's thesis, she worked on a multi-physics modeling project involving high-fidelity simulations of reactor physics and thermal hydraulics to analyze reactor cores.

South Korea exports its nuclear know-how widely, so work in the field can be immensely rewarding. Indeed, after graduate school, Choi moved to Daejeon, which has the moniker "Science City." As an intern at the Korea Atomic Energy Research Institute (KAERI), she conducted experimental studies on the passive safety systems of nuclear reactors. Choi then moved to the Korea Institute of Nuclear Nonproliferation and Control, where she worked as a researcher developing nuclear security programs for countries. Given South Korea's dominance in the field, other countries would tap its knowledge resource to tap their own nuclear energy programs. The focus was on international training programs, an arm of which involved cybersecurity and physical protection.

While the work was impactful, Choi found she missed the modeling work she did as part of her master's thesis. Looking to return to technical research, she applied to the MIT Department of Nuclear Science and Engineering (NSE). "MIT has the best nuclear engineering program in the States, and maybe even the world," Choi says, explaining her decision to enroll as a doctoral student.

Innovative research at MIT

At NSE, Choi is working to make SMRs more price competitive as compared to traditional nuclear energy power plants.

Due to their smaller size, SMRs are able to serve areas where larger reactors might not work, but they're more expensive. One way to address costs is to squeeze more electricity out of a unit of fuel — to increase the power density. Choi is doing so by replacing the traditional uranium dioxide ceramic fuel in a cylindrical shape with a metal one in a helical cruciform. Such a replacement potentially offers twin advantages: the metal fuel has high conductivity, which means the fuel will operate even more safely at lower temperatures. And the twisted shape gives more surface area and lower heat flux. The net result is more electricity for the same volume.

The project receives funding from a collaboration between Lightbridge Corp., which is exploring how advanced fuel technologies can improve the performance of water-cooled SMRs, and the U.S. Department of Energy Nuclear Energy University Program.

With SMR efficiencies in mind, Choi is indulging her love of multi-physics modeling, and focusing on reactor physics, thermal hydraulics, and fuel performance simulation. “The goal of this modeling and simulation is to see if we can really use this fuel in the SMR,” Choi says. “I’m really enjoying doing the simulations because the geometry is really hard to model. Because the shape is twisted, there’s no symmetry at all,” she says. Always up for a challenge, Choi learned the various aspects of physics and a variety of computational tools, including the Monte Carlo code for reactor physics.

Being at MIT has a whole roster of advantages, Choi says, and she especially appreciates the respect researchers have for each other. She appreciates being able to discuss projects with Shirvan and his focus on practical applications of research. At the same time, Choi appreciates the “exotic” nature of her project. “Even assessing if this SMR fuel is at all feasible is really hard, but I

think it's all possible because it's MIT and my PI [principal investigator] is really invested in innovation," she says.

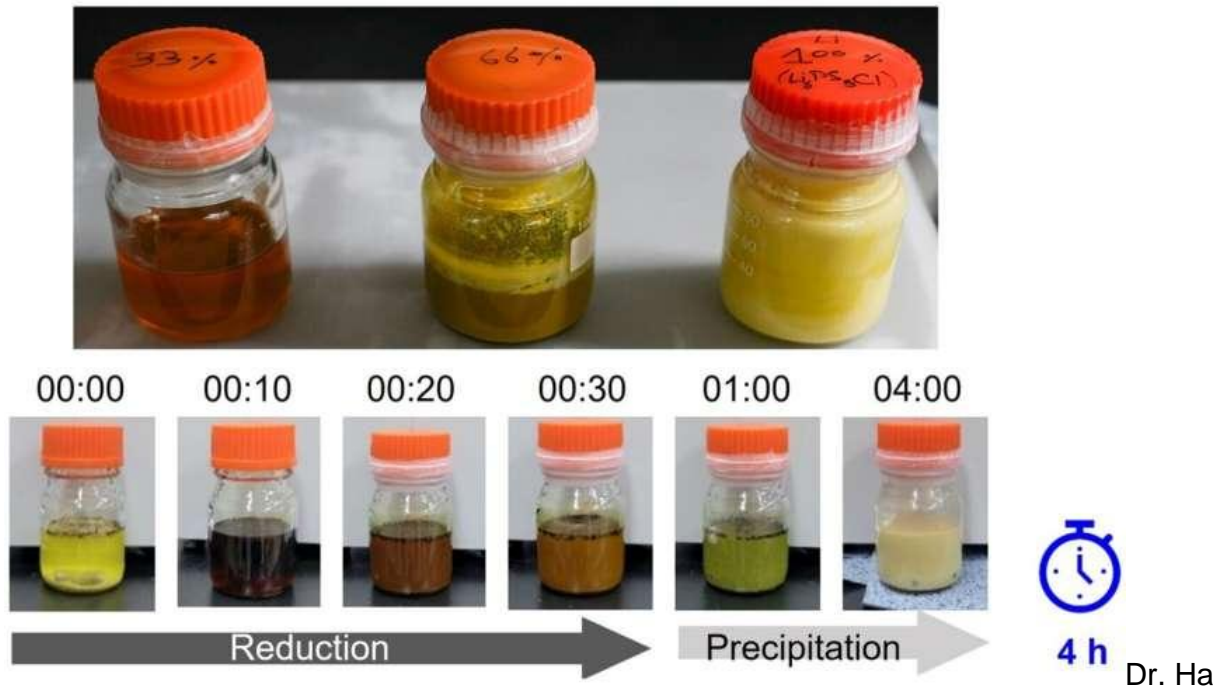
It's an exciting time to be in nuclear engineering, Choi says. She serves as one of the board members of the student section of the American Nuclear Society and is an NSE representative of the Graduate Student Council for the 2024-25 academic year.

Choi is excited about the global momentum toward nuclear as more countries are exploring the energy source and trying to build more nuclear power plants on the path to decarbonization. "I really do believe nuclear energy is going to be a leading carbon-free energy. It's very important for our collective futures," Choi says.

FEBRUARY 10, 2025

Faster and higher-quality production of lithium superionic conductors for all-solid-state batteries

by [National Research Council of Science and Technology](#)

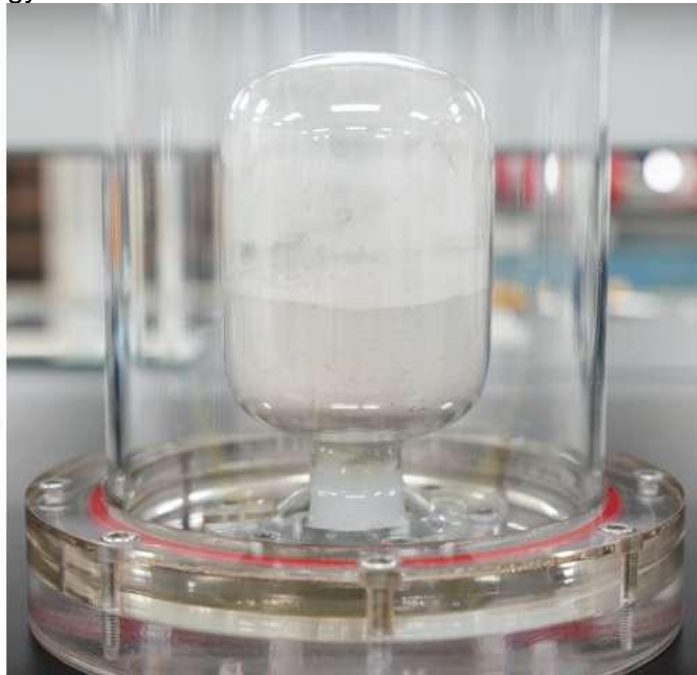


Yoon-Cheol's team at KERI analyzed the process in which lithium, sulfur, catalysts, phosphorus pentasulfide, and lithium chloride were mixed in optimal proportions, leading to the sequential formation and coprecipitation of intermediate species depending on the degree of lithium dissolution. Credit: Korea Electrotechnology Research Institute
Dr. Ha Yoon-Cheol's team at KERI's Next Generation Battery Research Center has developed an "enhanced coprecipitation method" that enables faster and higher-quality production of lithium superionic conductors for all-solid-state batteries (ASSBs). ASSB replaces the "electrolyte," which transfers ions between the anode and cathode, with a solid instead of a liquid, significantly reducing the risk of fire or explosion.

Solid electrolytes are difficult to manufacture and expensive. However, in 2021, Dr. Ha Yoon-Cheol's team garnered significant attention by proposing the "coprecipitation method," which enables large-scale production of [solid electrolytes](#) through a one-pot solution process, without the need for expensive lithium sulfide (Li_2S) by directly adding the raw materials into a single container. This method significantly reduces raw material costs compared to conventional methods and does not require high-energy milling or evaporation processes. The technology has been transferred to Daejoo Electronic Materials Co., Ltd., a domestic company specializing in electrical and electronic materials.

Since then, KERI has continued follow-up research with KAIST, Daejoo Electronic Materials Co., Ltd., and others. Through these efforts, they successfully identified the detailed mechanisms behind the dissolution and coprecipitation phenomena, leading to the development of an optimized, upgraded coprecipitation method that significantly shortens production time and dramatically improves the quality of solid electrolytes.

- Solid electrolyte powder for ASSBs, synthesized using the "upgraded coprecipitation method" developed by Dr. Ha Yoon-Cheol's team at KERI. Credit: Korea Electrotechnology Research Institute



- Dr. Ha Yoon-Cheol's team at KERI (right) has successfully developed a faster and higher-quality production method for solid electrolytes for ASSBs using the "upgraded coprecipitation method." Credit: Korea Electrotechnology Research Institute The key to the coprecipitation method is the process of evenly dissolving the raw materials in a solution, precipitating them, and then filtering them out. Dr. Ha Yoon-Cheol's team first mixed lithium, sulfur, and catalyst in the optimal proportions, and analyzed the process in which lithium polysulfides and lithium sulfide are sequentially formed depending on the degree of lithium dissolution.

They then applied this to the synthesis processes of three-element (such as Li_3PS_4) and four-element (such as $\text{Li}_6\text{PS}_5\text{Cl}$) solid electrolytes, developing a technology that enables rapid and homogeneous dissolution and coprecipitation of various raw materials.

The detailed mechanism analysis of KERI's coprecipitation method was carried out by top researchers from leading universities in Korea. Professor Byon Hye Ryung's team at KAIST led the chemical analysis of the intermediate species formed depending on the degree of lithium dissolution.

Additionally, quantum calculations and anion mass spectrometry conducted by Professor Baek Moo-Hyeon's team at KAIST and Professor Seo Jongcheol's team at POSTECH played a crucial role in uncovering the accurate molecular structures. Based on this, Daejoo Electronic Materials Co., Ltd. incorporated the technology related to continuous processes that will be applied in the actual mass production of solid electrolytes.

Through continuous collaboration between industry, academia, and research institutes, the upgraded coprecipitation method was developed, significantly reducing the production time of solid electrolytes from 14 hours to just 4 hours.

The quality of the optimally synthesized solid electrolytes has also been improved. Conventional manufacturing methods faced a persistent issue of lower ionic conductivity during the scale-up process. However, with the application of the upgraded coprecipitation method in the scale-up process, the ion conductivity of the solid electrolytes reached 5.7 mS/cm. This surpasses the level of liquid electrolytes (~4 mS/cm).

In addition, by applying the solid electrolytes to a 700mAh ASSB pouch cell, which is about one-fifth the capacity of a smartphone battery, an energy density of 352Wh/kg was achieved, surpassing the [energy density](#) of commercial lithium-ion batteries (270Wh/kg). Moreover, in experiments where the ASSB was charged and discharged 1,000 times, it maintained over 80% of its capacity, confirming its stable lifespan.

The research results were [published](#) in the journal *Energy Storage Materials*. The research team has confirmed that this technology can be applied not only to the synthesis of solid electrolytes but also to the production of various functional coatings. Recently, a patent for the technology has also been filed.

Dr. Ha Yoon-Cheol of KERI stated, "The previous achievement was significant in that it introduced the coprecipitation technology for the first time in the world to the manufacturing process of solid electrolytes, while this upgraded method is a result of optimizing the

principles of the coprecipitation method through detailed analysis, leading to better outcomes."

"This will serve as a key enabler for opening an era of mass production of ASSBs at a low cost."

More information: Mukarram Ali et al, Lithiation-driven cascade dissolution coprecipitation of sulfide superionic conductors, *Energy Storage Materials* (2024). [DOI: 10.1016/j.ensm.2024.103938](https://doi.org/10.1016/j.ensm.2024.103938)

Provided by [National Research Council of Science and Technology](#)
