Fusion energy: ITER completes world's largest and most powerful pulsed magnet system

Landmark achievement towards fusion energy

The sixth module of the Central Solenoid, completed at General Atomics in April 2025. When combined with the five other completed modules, the Central Solenoid will form the center of the ITER tokamak and the pulsed magnet system.

SAINT-PAUL-LEZ-DURANCE, FRANCE, April 30, 2025 /EINPresswire.com/ -- In a landmark achievement for fusion energy, ITER has completed all components for the world's largest, most powerful pulsed superconducting electromagnet system.

ITER is an international collaboration of more than 30 countries to demonstrate the viability of fusion—the power of the sun and stars—as an abundant, safe, carbon-free energy source for the planet.

The final component was the sixth module of the Central Solenoid, built and tested in the United States. When it is assembled at the ITER site in Southern France, the Central Solenoid will be the system's most powerful magnet, strong enough to lift an aircraft carrier.

The Central Solenoid will work in tandem with six ring-shaped Poloidal Field (PF) magnets, built and delivered by Russia, Europe, and China.

The fully assembled pulsed magnet system will weigh nearly 3,000 tons. It will function as the electromagnetic heart of ITER's donut-shaped reactor, called a Tokamak.

How does this pulsed superconducting electromagnet system work?
Step 1. A few grams of hydrogen fuel—deuterium and tritium gas—are injected into ITER's gigantic Tokamak chamber.
Step 2. The pulsed magnet system sends an electrical current to ionize the hydrogen gas, creating a plasma, a cloud of charged particles.

Step 3. The magnets create an “invisible cage” that confines and shapes the ionized plasma.
Step 4. External heating systems raise the plasma temperature to 150 million degrees Celsius, ten times hotter than the core of the sun.
Step 5. At this temperature, the atomic nuclei of plasma particles combine and fuse, releasing massive heat energy.


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At full operation, ITER is expected to produce 500 megawatts of fusion power from only 50 megawatts of input heating power, a tenfold gain. At this level of efficiency, the fusion reaction largely self-heats, becoming a “burning plasma.”

By integrating all the systems needed for fusion at industrial scale, ITER is serving as a massive, complex research laboratory for its 30-plus member countries, providing the knowledge and data needed to optimize commercial fusion power.

> This achievement proves that when humanity faces existential challenges like climate change and energy security, we can overcome national differences to advance solutions”
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> *Pietro Barabaschi, ITER Director-General*

ITER’s geopolitical achievement is also remarkable: the sustained collaboration of ITER’s seven members—China, Europe, India, Japan, Korea, Russia, and the United States. Thousands of scientists and engineers have contributed components from hundreds of factories on three continents to build a single machine.

Pietro Barabaschi, ITER Director-General, says, “What makes ITER unique is not only its technical complexity but the framework of international cooperation that has sustained it through changing political landscapes.”

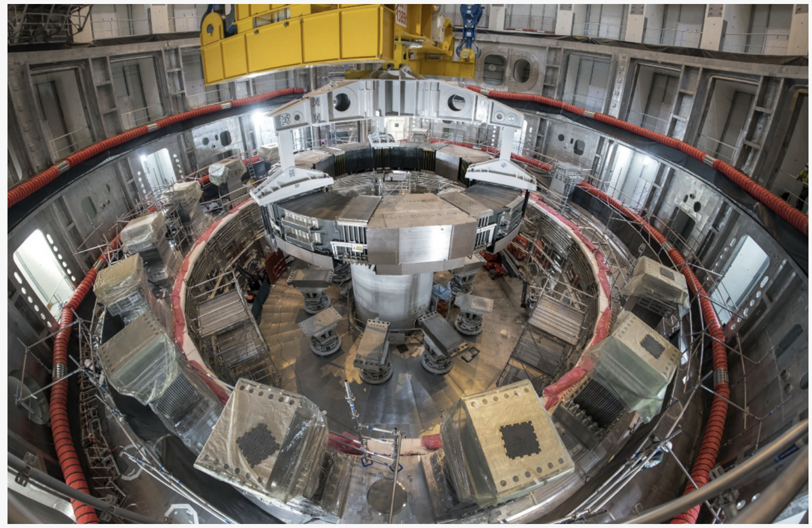
“This achievement proves that when humanity faces existential challenges like climate change and energy security, we can overcome national differences to advance solutions.”

“The ITER Project is the embodiment of hope. With ITER, we show that a sustainable energy future and a peaceful path forward are possible.”

In 2024, ITER reached 100% of its construction targets. With most of the major components delivered, the ITER Tokamak is now in assembly phase. In April 2025, the first vacuum vessel sector module was inserted into the Tokamak Pit, about 3 weeks ahead of schedule.

The past five years have witnessed a surge in private sector investment in fusion energy R&D. In November 2023, the ITER Council recognized the value and opportunity represented by this trend.

They encouraged the ITER Organization and its Domestic Agencies to actively engage with the private sector, to transfer ITER's accumulated knowledge to accelerate progress toward making fusion a reality.


Installation of the first superconducting magnet, Poloidal Field Coil #6, in the tokamak pit at the ITER construction site. The Central Solenoid will be mounted in the center after the vacuum vessel has been assembled.

In 2024, ITER launched a private sector fusion engagement project, with multiple channels for sharing knowledge, documentation, data, and expertise, as well as collaboration on R&D. This tech transfer initiative includes sharing information on ITER's global fusion supply chain, another way to return value to Member governments and their companies.

In April 2025, ITER hosted a public-private workshop to collaborate on the best technological innovation to solve fusion's remaining challenges.

The ITER experiment under construction in southern France. The tokamak building is the mirrored structure at center. Courtesy ITER Organization/EJF Riche.

Under the ITER Agreement, Members contribute most of the cost of building ITER in the form of building and supplying components. This arrangement means financing from each Member goes primarily to their own companies, to manufacture ITER's challenging technology. In doing so, these companies also drive innovation and gain expertise, creating a global fusion supply chain.

Europe, as Host Member, contributes 45% of the cost of the ITER Tokamak and its support systems. China, India, Japan, Korea, Russia, and the USA each contribute 9%, but all Members get access to 100% of the intellectual property.

The United States has
* Built the Central Solenoid, made of six modules, plus a spare.
* Delivered the "exoskeleton" support structure (comprised of 9,000+ individual parts manufactured by eight U.S. suppliers) that will enable the Central Solenoid to withstand the

extreme forces it will generate.
* Fabricated about 8% of the Niobium-Tin (Nb_3Sn) superconductors used in ITER's Toroidal Field magnets.

Russia has
* Delivered the 9-meter-diameter ring-shaped Poloidal Field magnet that will crown the top of the ITER Tokamak.
* Working closely with Europe, produced approximately 120 tonnes of Niobium-Titanium (NbTi) superconductors, comprising about 40% of the total required for ITER's Poloidal Field magnets.
* Manufactured giant busbars that will deliver power to the magnets at the required voltage and amperage, as well as the upper port plugs for ITER's vacuum vessel sectors.

Europe has
* Manufactured four of the ring-shaped Poloidal Field magnets onsite in France, ranging from 17 to 24 meters in diameter.
* Delivered 10 of ITER's Toroidal Field magnets and produced a substantial portion of the Niobium-Tin (Nb_3Sn) superconductors used in these TF magnets.
* and as creating five of the nine sectors of the Tokamak vacuum vessel, the donut-shaped chamber where fusion will take place.

China, under an arrangement with Europe, has
* Manufactured a 10-metre Poloidal Field magnet, already installed at the bottom of the partially assembled ITER Tokamak.
* Contributed the NbTi superconductors for PF magnets 2, 3, 4, and 5, about 65% of the PF magnet, andabout 8% of the Toroidal Field magnet superconductors.

News release in full: https://conta.cc/3ErV2tl

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