ITER...
THE WAY TO NEW ENERGY

China, European Union, India, Japan, Korea, Russia, United States

www.iter.org

ITER ("The Way" in Latin) is designed to demonstrate the scientific and technological feasibility of fusion energy.

WHAT IS FUSION?

Fusion is the process that occurs within the core of the Sun and stars. What we see as light and feel as warmth is the result of fusion reactions: hydrogen nuclei collide, fuse into heavier helium atoms, and release considerable amounts of energy in the process. Fusion is the source of life in the Universe.

In the Sun and stars, gravitational forces create the necessary conditions for fusion. On Earth, fusion can be achieved through "magnetic confinement" – a technique that involves high temperature plasmas and intense magnetic fields.

ITER is a large-scale scientific experiment that aims to demonstrate that it is possible to produce commercial energy from fusion. It represents the culmination of sixty years of research in plasma physics carried out on hundreds of fusion machines throughout the world. Experiments run on ITER – the largest fusion device ever built – will provide the data necessary for the design and subsequent operation of the first electricity-producing fusion power plant.

The ITER Project is a unique international collaboration that brings together China, the European Union, India, Japan, Korea, Russia and the United States. The seven ITER Members – 35 individual nations, representing 80% of the world's GDP and half the planet's population – will share the responsibility for designing, building and operating the ITER installation.

By unanimous decision in 2005, the ITER Members chose a site proposed by the European Union in southern France as the location for the project. Following the establishment of the ITER Organization and preparatory site works, construction of the buildings began in August 2010.

The ITER experimental facility will be operational in the next decade.

Cover page: On the ITER construction site the tall structure of the Assembly Building (60 metres in height) now dominates the landscape.

WELCOME TO THE MACHINE

The ITER device is a tokamak – a Russian acronym meaning "toroidal chamber with magnetic coils." Tokamaks are fusion devices that were developed in the late 1950s and 1960s in the Soviet Union and quickly adopted by most fusion laboratories throughout the world.

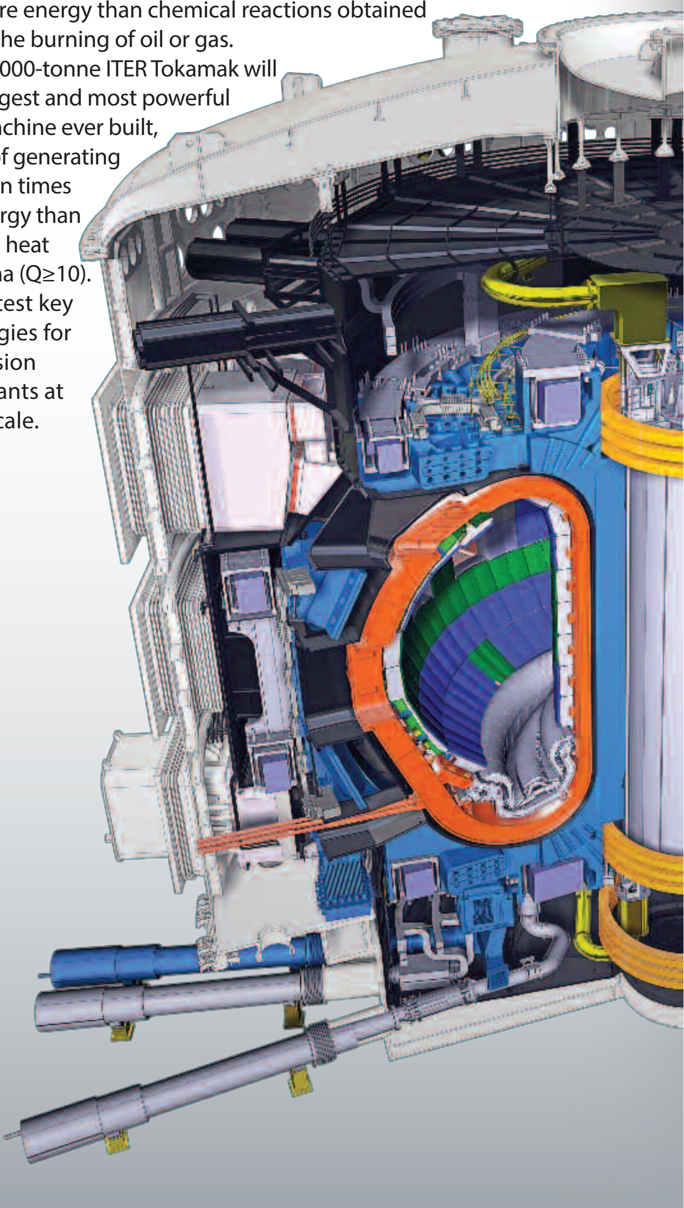
In the past 50 years, progress in tokamaks has been as steady and as spectacular as the growth in the performance of microprocessors – indeed slightly better. Key fusion parameters have increased by a factor of 10 million.

In the ITER Tokamak, a 50/50 gaseous mix of hydrogen isotopes deuterium and tritium will be contained in a doughnut-shaped vacuum vessel and heated to temperatures in excess of 150 million °C to form a hot plasma.

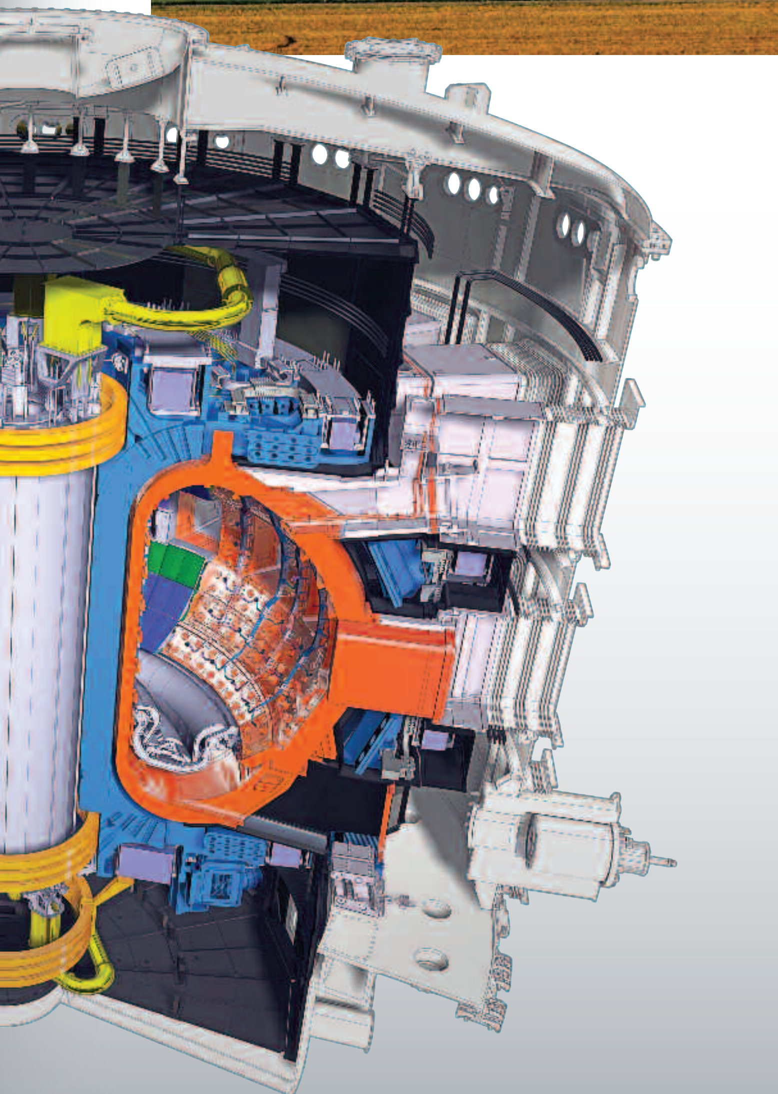
Intense magnetic fields produced by an array of giant superconducting coils and a strong electrical current will shape and confine the plasma, keeping it away from the vessel walls.

The fusion reactions in the plasma will release four million times more energy than chemical reactions obtained through the burning of oil or gas.

The 23,000-tonne ITER Tokamak will be the largest and most powerful fusion machine ever built, capable of generating at least ten times more energy than it takes to heat the plasma (Q≥10). ITER will test key technologies for future fusion power plants at reactor scale.



A view of the platform taken from the village of Vinon-sur-Verdon (5 km distant). From left to right: the Cryostat Workshop; the Assembly Building; tall cranes over the Tokamak Complex worksite; ITER Headquarters; and a component storage facility (in yellow).



The ITER Tokamak is the most complex machine ever built.

WE ARE
BUILDING

Construction began on the ITER scientific facility in Saint-Paul-lez-Durance, France, in August 2010.

From August 2010 to August 2014, large-scale works were carried out to create the ground support structure and reinforced foundations of the Tokamak Complex – the massive structure that will house the ITER fusion experiments.

Civil works are now underway on the first of the building's seven levels. At least four years will be necessary to complete the concrete structure and to install all electrical and mechanical equipment.

Nearby, work also advances on the Assembly Building, a 6,000 m^2 hall where the pre-assembly activities on ITER components will be carried out with specialized, purpose-built tools. The heavy steel structure of the building is in place and work has started to prepare for the installation of two independent bridge cranes; during ITER assembly, these cranes will operate along the entire length of the Tokamak and Assembly buildings to handle component loads of up to 1,500 tonnes.

Once completed, the Tokamak and Assembly buildings will stand 60 metres tall.

For two of ITER's largest components, dedicated manufacturing and assembly facilities have been realized on site. Both the winding facility for the poloidal field magnets and the assembly workshop for the 30x30 metre ITER cryostat are ready to receive the first tooling stations and to begin commissioning activities.

In other areas of the construction platform, work is underway on a number of auxiliary buildings that will support the ITER plant. Thirty-nine buildings and technical areas in all – financed and supervised by the European Domestic Agency (Fusion for Energy) as part of its contribution to the ITER Project – will be realized on the 42-hectare ITER platform.

From just a few hundred today, the number of construction workers is expected to rise to over 3,000 during the peak of construction and assembly activities in 2017-2020.

china eu india japan korea russia usa

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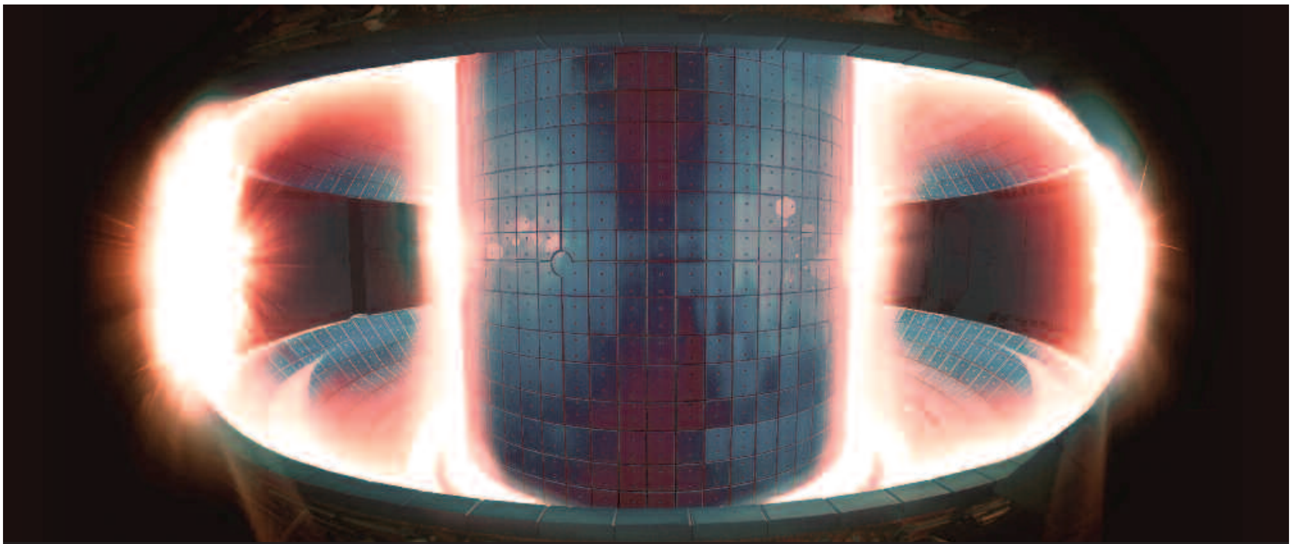

A plasma in Korea's KSTAR tokamak. Throughout the world, dozens of fusion machines have paved the way to ITER.

WHY WE NEED FUSION

By the end of the century, demand for energy will have tripled under the combined pressure of population growth, increased urbanization and expanding access to energy in developing countries. A new large-scale, sustainable and carbon-free form of energy is urgently needed. The following advantages make fusion worth pursuing.

Abundant energy: Fusing atoms together releases nearly *four million times* more energy than a chemical reaction such as the burning of coal, oil or gas and *four times* as much as nuclear fission reactions (at equal mass). Fusion has the potential to provide the kind of baseload energy needed to provide electricity to our cities and our industries.

Sustainability: Fusion fuels are widely available and nearly inexhaustible. Deuterium can be distilled from all forms of water. Tritium can be produced during the fusion reaction as fusion neutrons interact with lithium – and lithium from proven, easily extractable land-based resources would be enough to operate fusion power plants for more than 1,000 years.

No greenhouse gases: Fusion doesn't emit carbon dioxide or other greenhouse gases into the atmosphere.

No long-lived radioactive waste: Unlike fission reactors, nuclear fusion reactors produce no high activity, long-lived nuclear waste.

No proliferation: Fusion doesn't employ fissile materials that could be exploited to make nuclear weapons.

No risk of meltdown: A Fukushima-type nuclear catastrophe is not possible in a tokamak fusion device. If any disturbance occurs, the plasma cools within seconds and the reaction stops.

"Nuclear fusion holds the promise of an inexhaustible, clean and safe source of energy – one of the dreams of humankind. If this dream can be realized, it will have dramatic implications for the future on many levels, from economic growth to climate change and fighting poverty."

Yukiya Amano, Director General of the International Atomic Energy Agency (IAEA), official visit to ITER, 6 July 2012

"Europe is proud to believe in ITER… The future of our continent is in science and innovation."

José-Manuel Barroso, President of the European Commission, official visit to ITER, 11 July 2014

"ITER is a very good example of long-term vision and international cooperation… The project truly shows that securing tomorrow's energy demands vision and investment now."

Pierre Gadonneix, president of the World Energy Council, Monaco ITER International Fusion Energy Days (MIIFED), 4 December 2013

"I would like nuclear fusion to become a practical power source. It would provide an inexhaustible supply of energy, without pollution or global warming."

Stephen Hawking, physicist, cosmologist, *Time Magazine*, 15 November 2010