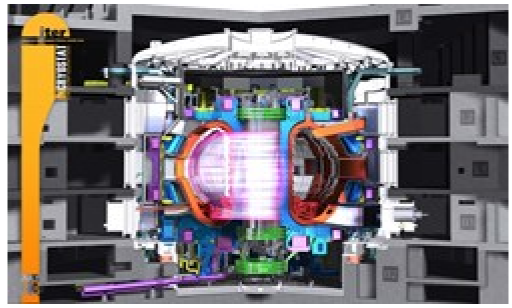
What is ITER?

About | What is ITER?



ITER ("The Way" in Latin) is one of the most ambitious energy projects in the world today.

In southern France, 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.

The experimental campaign that will be carried out at ITER is crucial to advancing fusion science and preparing the way for the fusion power plants of tomorrow.

ITER will be the first fusion device to produce **net energy**. ITER will be the first fusion device to maintain fusion for long periods of time. And ITER will be the first fusion device to test the integrated technologies, materials, and physics regimes necessary for the commercial production of fusion-based electricity.

Thousands of engineers and scientists have contributed to the design of ITER since the idea for an international joint experiment in fusion was first launched in 1985. The ITER Members—**China, the European Union, India, Japan, Korea, Russia and the United States**—are now engaged in a 35-year collaboration to build and operate the ITER experimental device, and together bring fusion to the point where a demonstration fusion reactor can be designed.

We invite you to explore the ITER website for more information on the science of ITER, the ITER international collaboration and the large-scale building project that is underway in Saint Paul-lez-Durance, southern France.

What will ITER do?

The amount of fusion energy a tokamak is capable of producing is a direct result of the number of fusion reactions taking place in its core. Scientists know that the larger the vessel, the larger the volume of the plasma ... and therefore the greater the potential for fusion energy.

Q ≥ 10

With ten times the plasma volume of the largest machine operating today, the ITER Tokamak will be a unique experimental tool, capable of longer plasmas and better confinement. The machine has been designed specifically to:

1) Produce 500 MW of fusion power

The world record for fusion power is held by the European tokamak JET. In 1997, JET produced 16 MW of fusion power from a total input power of 24 MW (Q=0.67). ITER is designed to produce a ten-fold return on energy (Q=10), or **500 MW of fusion power from 50 MW of input power**. ITER will not capture the energy it produces as electricity, but—as first of all fusion experiments in history to produce net energy gain—it will prepare the way for the machine that can.

2) Demonstrate the integrated operation of technologies for a fusion power plant
ITER will bridge the gap between today's smaller-scale experimental fusion devices and the demonstration fusion power plants of the future. Scientists will be able to study plasmas under conditions similar to those expected in a future power plant and test technologies such as heating, control, diagnostics, cryogenics and remote maintenance.

3) Achieve a deuterium-tritium plasma in which the reaction is sustained through internal heating
Fusion research today is at the threshold of exploring a "burning plasma"—one in which the heat from the fusion reaction is confined within the plasma efficiently enough for the reaction to be sustained for a long duration. Scientists are confident that the plasmas in ITER will not only produce much more fusion energy, but will remain stable for longer periods of time.

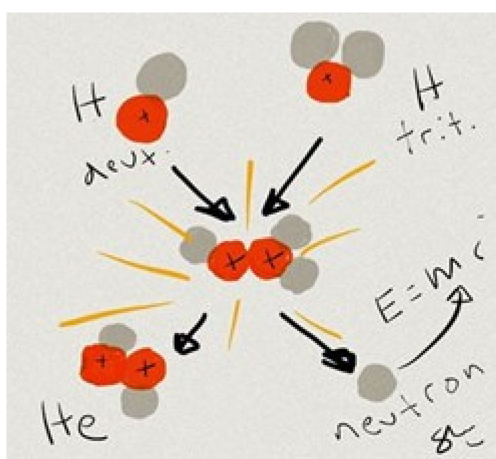
4) Test tritium breeding
One of the missions for the later stages of ITER operation is to demonstrate the feasibility of producing tritium within the vacuum vessel. The world supply of tritium (used with deuterium to fuel the fusion reaction) is not sufficient to cover the needs of future power plants. ITER will provide a unique opportunity to test mockup in-vessel tritium breeding blankets in a real fusion environment.

5) Demonstrate the safety characteristics of a fusion device
ITER achieved an important landmark in fusion history when, in 2012, the ITER Organization was licensed as a nuclear operator in France based on the rigorous and impartial examination of its safety files. One of the primary goals of ITER operation is to demonstrate the control of the plasma and the fusion reactions with negligible consequences to the environment.

https://www.iter.org/proj/inafewlines Go NOV DEC FEB 08 2014 2015 2016
83 captures
21 Nov 2015 - 3 Dec 2017
About this capture

What is fusion?

Fusion is the energy source of the Sun and stars. In the tremendous heat and gravity at the core of these stellar bodies, hydrogen nuclei collide, fuse into heavier helium atoms and release tremendous amounts of energy in the process.



Twentieth-century fusion science identified the most efficient fusion reaction in the laboratory setting to be the reaction between two hydrogen isotopes, deuterium (D) and tritium (T). The DT fusion reaction produces the highest energy gain at the "lowest" temperatures.

Three conditions must be fulfilled to achieve fusion in a laboratory: very high temperature (on the order of 150,000,000° Celsius); sufficient plasma particle density (to increase the likelihood that collisions do occur); and sufficient confinement time (to hold the plasma, which has a propensity to expand, within a defined volume).

At extreme temperatures, electrons are separated from nuclei and a gas becomes a plasma—often referred to as the fourth state of matter. Fusion plasmas provide the environment in which light elements can fuse and yield energy.

In a tokamak device, powerful magnetic fields are used to confine and control the plasma.

*See the Science section for more on **fusion** and **plasmas**.*

What is a tokamak?

Power plants today rely either on fossil fuels, nuclear fission, or renewable sources like wind or water. Whatever the energy source, the plants generate electricity by converting mechanical power, such as the rotation of a turbine, into electrical power. In a coal-fired steam station, the combustion of coal turns water into steam and the steam in turn drives turbine generators to produce electricity.

Visualization courtesy of Jamison Daniel, Oak Ridge Leadership Computing Facility

The **tokamak** is an experimental machine designed to harness the energy of fusion. Inside a tokamak, the energy produced through the fusion of atoms is absorbed as heat in the walls of the vessel. Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators.

The heart of a tokamak is its doughnut-shaped vacuum chamber. Inside, under the influence of extreme heat and pressure, gaseous hydrogen fuel becomes a plasma—the very environment in which hydrogen atoms can be brought to fuse and yield energy. (You can read more on this particular state of matter **here**.) The charged particles of the plasma can be shaped and controlled by the massive magnetic coils placed around the vessel; physicists use this important property to confine the hot plasma away from the vessel walls. The term "tokamak" comes to us from a Russian acronym that stands for "toroidal chamber with magnetic coils."

First developed by Soviet research in the late 1960s, the tokamak has been adopted around the world as the most promising configuration of magnetic fusion device. ITER will be the world's largest tokamak—twice the size of the largest machine currently in operation, with ten times the plasma chamber volume.

*See the **Machine** section for more on the Tokamak and its components.*

Who is participating?

The ITER Project is a globe-spanning collaboration of 35 nations.

The ITER Members **China**, the **European Union**, **India**, **Japan**, **Korea**, **Russia** and the **United States** have combined resources to conquer one of the greatest frontiers in science—reproducing on Earth the boundless energy that fuels the Sun and the stars.

As signatories to the ITER Agreement, concluded in 2006, the seven Members will share of the cost of project construction, operation and decommissioning. They'll also share the experimental results and any intellectual property generated by the operation phase.

Europe is responsible for the largest portion of construction costs (45.6 percent); the remainder is shared equally by China, India, Japan, Korea, Russia and the US (9.1 percent each). The Members deliver very little monetary contribution to the project: instead, nine-tenths of contributions will be delivered to the ITER Organization in the form of completed components, systems or buildings.

Taken together, the ITER Members represent three continents, over 40 languages, half of the world's population and 85 percent of global gross domestic product. In the offices of the ITER Organization (the Central Team) and those of the seven Domestic Agencies, in laboratories and in industry, literally thousands of people are working toward the success of ITER.

See the Members page for links to the seven Domestic Agencies.

When will experiments begin?

The ITER scientific facility is under construction now in southern France.

On a cleared, 42-hectare site, building has been underway since 2010. The ground support structure and the seismic foundations of the ITER Tokamak are in place and work has begun on the Tokamak Complex—a suite of three buildings that will house the fusion experiments. Work is also beginning on auxiliary plant buildings such as the ITER cryoplant, the control building, and facilities for cooling water, power conversion, power supply.

As soon as access to the Tokamak Building is possible, scientists and engineers will progressively assemble, integrate, and test the ITER fusion device. Commissioning will ensue to verify that all systems function together and to prepare the ITER machine for operation.

The successful integration and assembly of over one million components (ten million parts), built in the ITER Members' factories around the world and delivered to the ITER site constitutes a tremendous logistics and engineering challenge. The assembly workforce, both at ITER and in the Domestic Agencies, will reach 2,000 people at the height of assembly activities. In the ITER offices around the world, the exact sequence of assembly events has been carefully orchestrated and coordinated beginning with the arrival of the first large components on the ITER site in 2015.

ITER Timeline

2005	Decision to site the project in France
2007	Formal creation of ITER Organization
2007-2009	Land clearing and levelling
2010-2014	Ground support structure and seismic **foundations** for the Tokamak
2012	Nuclear licensing milestone: ITER becomes a Basic Nuclear Installation under French law
Nov 2014-to present*	Construction of the Tokamak Complex
Aug 2010-to present*	Construction of the ITER plant and auxiliary buildings
2008-to present*	Manufacturing of machine and plant components
Jan 2015-to present*	Largest components are transported along the ITER Itinerary
Start date tbc*	Assembly phase
Start date tbc*	Commissioning phase
Start date tbc*	First Plasma
Start date tbc*	Deuterium-tritium operation begins

** The ITER Organization presented an updated project schedule to the seventeenth meeting of the ITER Council on 18-19 November 2015. This schedule is based on an in-depth bottom-up review and analysis of all aspects of manufacturing and assembling the ITER systems, structures and components through the completion of construction, assembly and commissioning.*

The Council acknowledged the much-improved understanding of the scope, sequencing, risks, and costs of the ITER Project achieved by this systematic and integrated analysis and review. It approved a schedule and milestones covering 2016-2017, allowing ITER to keep the momentum on construction and manufacturing activities.

ITER's governing body decided to conduct an independent review of the overall schedule and associated resources and to consider possible additional measures for expediting the schedule and reducing costs. The Council plans to complete these reviews—and reach agreement on the overall schedule through First Plasma—by June 2016.

The Council will closely monitor the performance of the ITER Organization and Domestic Agencies in meeting the 2016-2017 milestones. The Council approved the re-allocation of the necessary funding, over a period of two years, to enable adherence to these milestones.

See the **Building ITER** page for more information on ITER construction and assembly.