ITER: World's largest nuclear FUSION project begins assembly

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In NEWS

- The world's biggest nuclear fusion project has entered its five-year assembly phase. After this is finished, the facility will be able to start generating the super-hot "plasma" required for fusion power. The £18.2bn (€20bn; $23.5bn) facility has been under construction in Saint-Paul-lez-Durance, southern France.
- Advocates say fusion could be a source of clean, unlimited power that would help tackle the climate crisis.
- ITER is a collaboration between China, the European Union, India, Japan, South Korea, Russia and the US. All members share in the cost of construction.
- “Current nuclear energy relies on fission, where a heavy chemical element is split to produce lighter ones. Nuclear fusion, on the other hand, works by combining two light elements to make a heavier one. This releases vast amounts of energy with very little radioactivity”
- Iter will confine hot plasma within a structure called a tokamak in order to control fusion reactions.
- The project will aim to help demonstrate whether fusion can be commercially viable. France's President Emmanuel Macron said the effort would unite countries around a common good.

ITER Timeline

2005: Decision to site the project in France
2006: Signature of the ITER Agreement
2007: Formal creation of the 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
2014-2021: Construction of the Tokamak Building (access for assembly activities in 2019)
2010-2021: Construction of the ITER plant and auxiliary buildings for First Plasma
2008-2021: Manufacturing of principal First Plasma components
2015-2023: Largest components are transported along the ITER Itinerary
2020-2025: Main assembly phase I
2022: Torus completion
2024: Cryostat closure
2024-2025: Integrated commissioning phase (commissioning by system starts several years earlier)
Dec 2025 First Plasma
2025-2035: Progressive ramp-up of the machine
2035: Deuterium-Tritium Operation begins

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. 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 heating 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 heating 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.

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
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.

For further READING: https://www.iter.org/proj/inafewlines