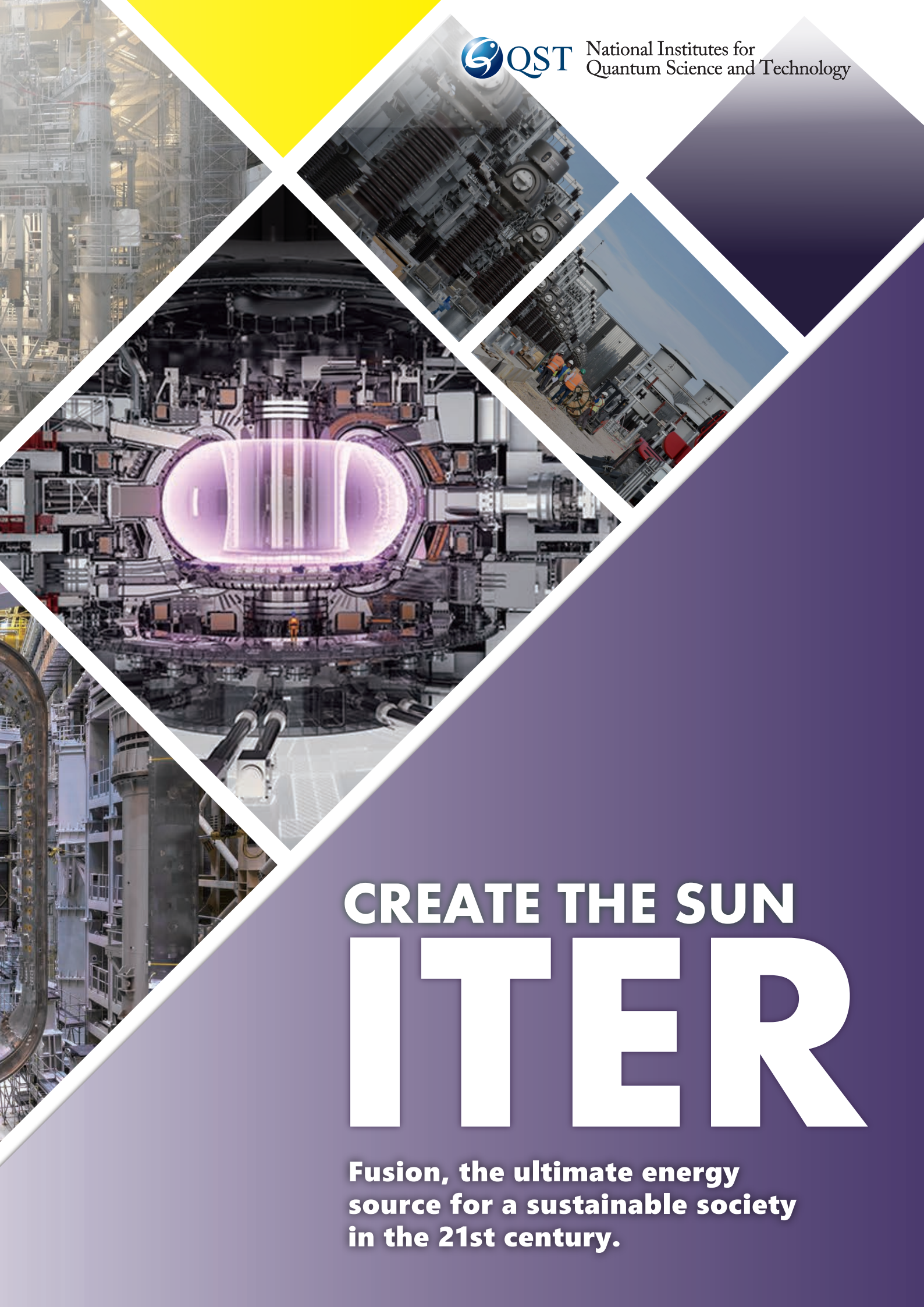


QST National Institutes for Quantum Science and Technology

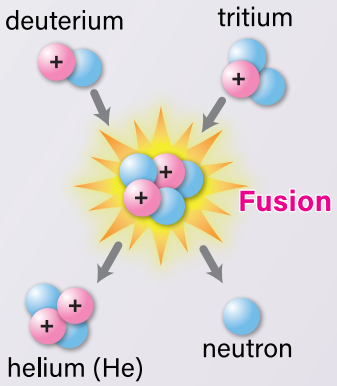
CREATE THE SUN

ITER

Fusion, the ultimate energy source for a sustainable society in the 21st century.

Sustainable Energy
What is Fusion?

Fusion—the source of power for the stars in the universe, including the Sun—is the process by which hydrogen nuclei collide at incredible speeds and "fuse" into heavier atoms, releasing tremendous amounts of energy in the process.
On Earth, however, fusion reactions are most easily replicated by fusing isotopes of hydrogen (deuterium and tritium) at high temperatures.



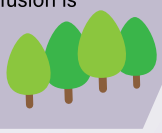
The 4 tenets of fusion

POINT 01 Virtually inexhaustible fuel resources

The fusion fuel, deuterium and lithium, are readily extracted from sea water and provide a secure source of energy.
The fuel is considered to be inexhaustible.

POINT 02 Environmentally friendly

Fusion doesn't emit carbon dioxide or other greenhouse gases into the atmosphere and doesn't produce high-level radioactive waste. All waste generated by fusion is low-level and can be safely managed.



POINT 03 Inherently safe

If any disturbance occurs, the plasma cools within seconds and the reaction stops with no risk of a meltdown. Tritium is used as a fuel but the techniques for the safe storage and handling of tritium are well developed, and ITER has been designed with strict safety measures to ensure containment.

POINT 04 Power generation efficiency

Can generate a lot of electricity with little fuel.

1 g of fusion fuel = 8 t petroleum

What is"the ITER Project"?

The ITER Project is an ambitious energy project of unprecedented scale and involves more than 30 countries collaborating under the ITER Agreement.

The goal of the ITER Project is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes.

Together, the ITER members-China, the EU, India, Japan, South Korea, Russia, and the US- represent about half of the world's population and three quaters of the global gross domestic product.ct.

QST-ITER Japan Domestic Agency

The ITER Agreement mandates that the parties, through their respective domestic agencies, procure and deliver approximately 90% of the ITER components to the ITER site. Designated as Japan's domestic agency for the ITER Project, QST is in charge of manufacturing and delivering commissioned components and equipment, such as the superconducting coils.
QST also serves as a liaison and coordination office for dispatching Japanese personnel to contribute to the ITER Project.

ITER Organization

The international governing body for the ITER Project

The ITER Organization was officially established on October 24th, 2007, the same day the ITER Agreement came into effect. The ITER Organization oversees the construction and operation of ITER and is located in Saint-Paul-lez-Durance, France.

The ITER Project is progressing steadily in cooperation with the domestic agencies for the seven parties of the ITER Agreement.


ITER Agreement Signing Ceremony (Paris, 2006)

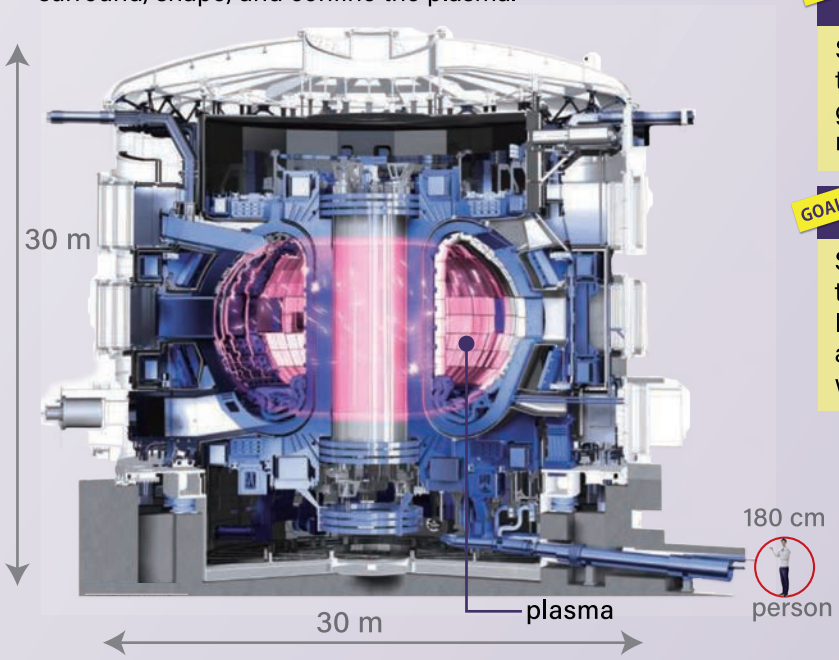
Dispatching staff to the ITER Organization

Liaison office for talent acquisition from Japan

The ITER Organization has more than 1,000 employees from over 30 countries around the world. ITER hires candidates from the participating ITER Members countries, including Japan. ITER Japan, the Domestic Agency of Japan, introduces open positions at ITER, assists with the application process, and provides training for applicants.
We work together with the government to ensure as many Japanese staff as possible can work at the ITER Organization.

The ITER tokamak

ITER is a doughnut-shaped vacuum chamber, which allows for sufficient temperature, pressure, and confinement time to create a plasma in which fusion can occur.
This superheated plasma, the fuel for the fusion process, is electrically conductive, and can thus be manipulated by electrical or magnetic fields.
Think of iron filings in the presence of a magnet, except in ITER's case, the magnets are giant superconducting coils that surround, shape, and confine the plasma.



The 3 Goals of ITER

GOAL 01 **Demonstrate a burning (self-heating) plasma**

ITER has been designed for high fusion power gain.
For 50 MW of power injected into the ITER machine via the systems that heat the plasma it will produce 500 MW of fusion power for periods of 300 to 500 seconds.
This tenfold return is expressed by Q ≥ 10 (ratio of heating input power to thermal output power).

GOAL 02 **Demonstrate the integrated operation of technologies for a fusion power plant**

Scientists can study plasmas under conditions similar to those envisaged in a future power plant and test technologies such as heating, control, diagnostics, cryogenics, and remote maintenance in an integrated way.

GOAL 03 **Recovery of heat energy and tritium breeding tests**

Scientists will conduct experiments for extracting heat from the fusion energy generated by burning plasmas.
In later stages of ITER operation, tritium breeding tests will aim to demonstrate the feasibility of producing tritium within the vacuum vessel.

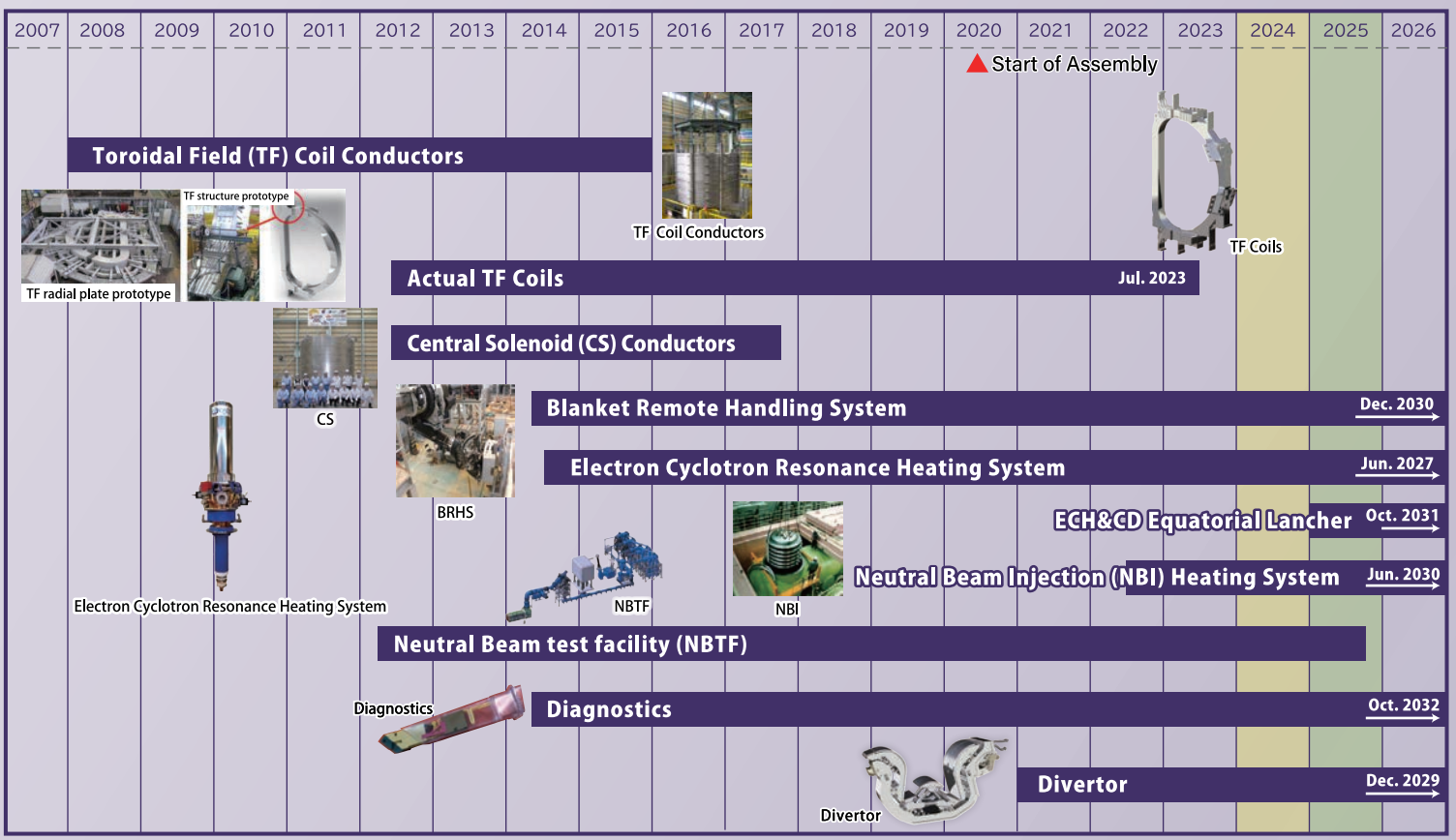
Main specifications of ITER

Plasma Major Radius	6.2 m
Machine Weight	23,000 t
Fusion Power	500 MW

Procurement activities of Japan

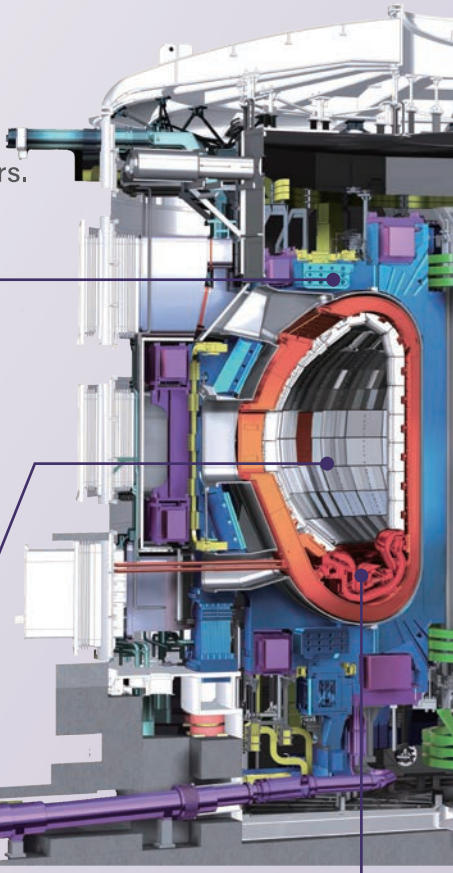
Procurement schedule of Japan

Procurement activities are developed in cooperation with the ITER Organization and other Domestic Agencies.
Japan has made leading contributions to the ITER Project with the manufacture of the TF coils and neutral beam injectors.



Procurement activities of ITER Japan Domestic Agency

Japan contributes to the construction of ITER by procuring the major components of ITER, in collaboration with the ITER Organization and participating ITER Members.

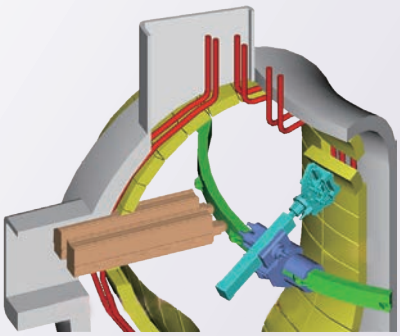


Toroidal Field Coils (TF Coils)

Superconducting coils that generate magnetic fields to confine high temperature plasma

Device	Japan Procurement	Progress
TF Conductors	33 (25%)	All conductor unit lengths delivered (2015)
TF Structures	19 (100%) Includes 1 spare	All production completed (2021)
TF Winding and Integration	9 (47%) Includes 1 spare	All production completed (2023)

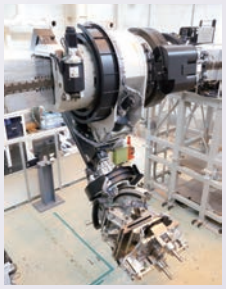
Shipment status All shipments and deliveries completed



Remote Handling System

Remote handling equipment to maintain and replace the shield blankets

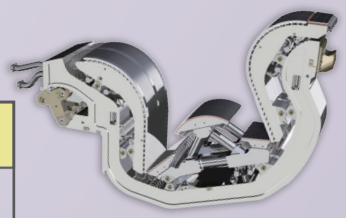
Device	Japan Procurement	Progress
Blanket Remote Handling System and tooling	100%	Final design 65% achieved



Robotic arm for fusion reactor maintenance and inspection

Divertor

Device that extracts helium and impurities produced by the fusion reaction



Device	Japan Procurement	Progress
Outer Targets	58 (100%) Includes 4 spare	Equipment fabrication 7% achieved

FUSION Boy

The TF coils are among the largest components of the ITER machine, 9 × 17 meters and weighing 360 tonnes.

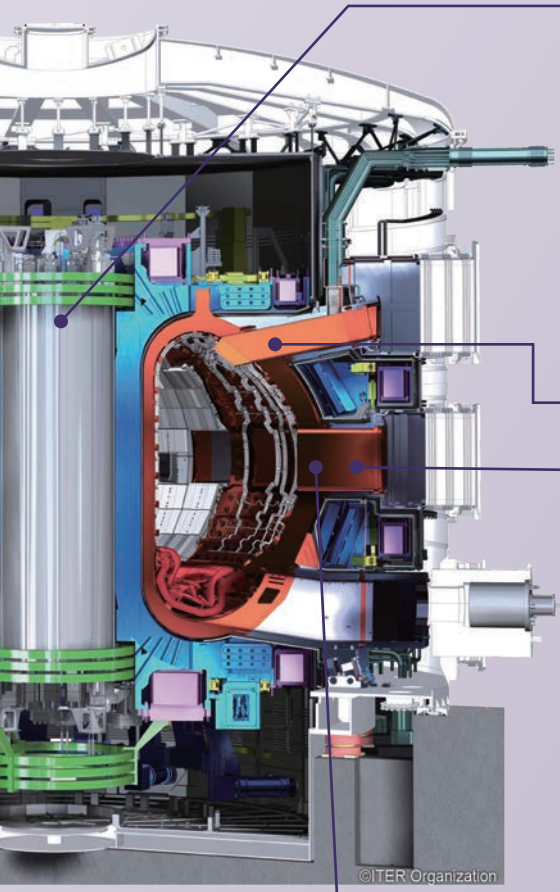
The eighth TF coil is being shipped. Mar. 2023

Ceremony held at Toshiba Energy Systems Corporation to celebrate the completion of the final ITER toroidal field coil for the experimental nuclear fusion reactor. Feb. 2023

ITER Girl

Delivery goes from Japan to France by sea and from the port to ITER construction site goes to dedicated overland routes.

This is a view of the delivery of the third TF coil. Mar. 2021

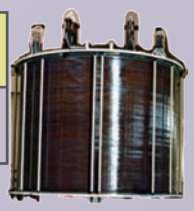


ITER tokamak

Central Solenoid (CS)

The key superconducting coils that generate powerful magnetic flux to start-up, control, and shut-down the plasma

Device	Japan Procurement	Progress
CS Conductors	49 (100%)	All conductor unit lengths delivered (2017)



Shipment status All shipments and deliveries completed.

Diagnostics

Diagnostic systems for measuring the density and temperature of ions and electrons in the plasma, the distribution of impurities, and for monitoring neutron flux.

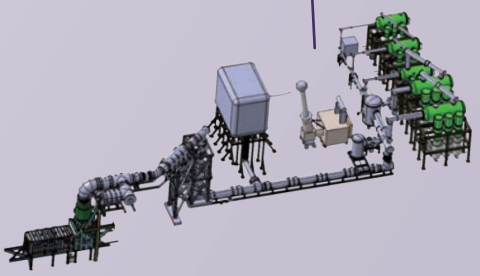
Device	Japan Procurement	Progress
• Micro Fission Chamber • Edge Thomson Scattering System • Poloidal Polarimeter • Divertor Impurity Monitor • Divertor IR Thermography	Approximately 15%	Final design 50% achieved Equipment fabrication 18% achieved
Lower Port		Preliminary design completed

Electron Cyclotron Resonance Heating System

Plasma heating device using electromagnetic waves, based on the similar principle as a microwave oven

Device	Japan Procurement	Progress
Gyrotron	8 (33%)	All manufacturing completed (2021)
RF launchers	50%	Final design 90% achieved

Shipment status 6 out of 8 gyrotrons shipped and delivered to the ITER site



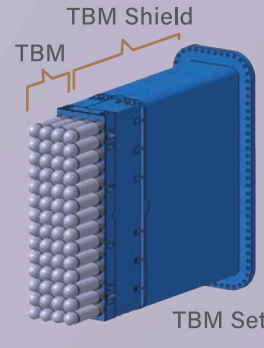
Neutral Beam Injector

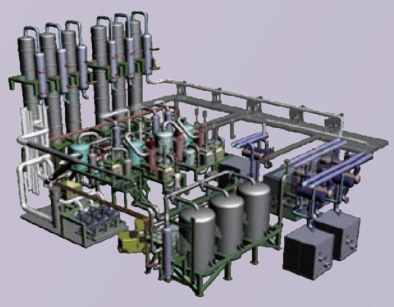
Plasma heating device that injects high-energy neutral particle beams into the plasma

Device	Japan Procurement	Progress
1 MV high-voltage direct current power supply system	3 (100%)	Final design 87% achieved
High-voltage (HV) bushing	3 (100%)	Final design 70% achieved
1 MeV accelerator	1 (33%)	Final design 78% achieved

Test Blanket Modules (TBM)

Equipment for extracting the heat energy generated by the fusion reaction. Used for tests to produce fuel necessary for fusion(tritium).





Tritium Removal Plant

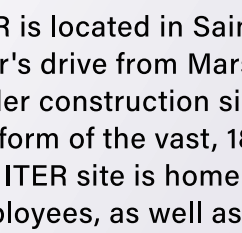
Facility that removes tritium from tritiated components and materials. The separated tritium is purified and treated to be reused. A detritiation system also removes tritium released during the recycling processes.

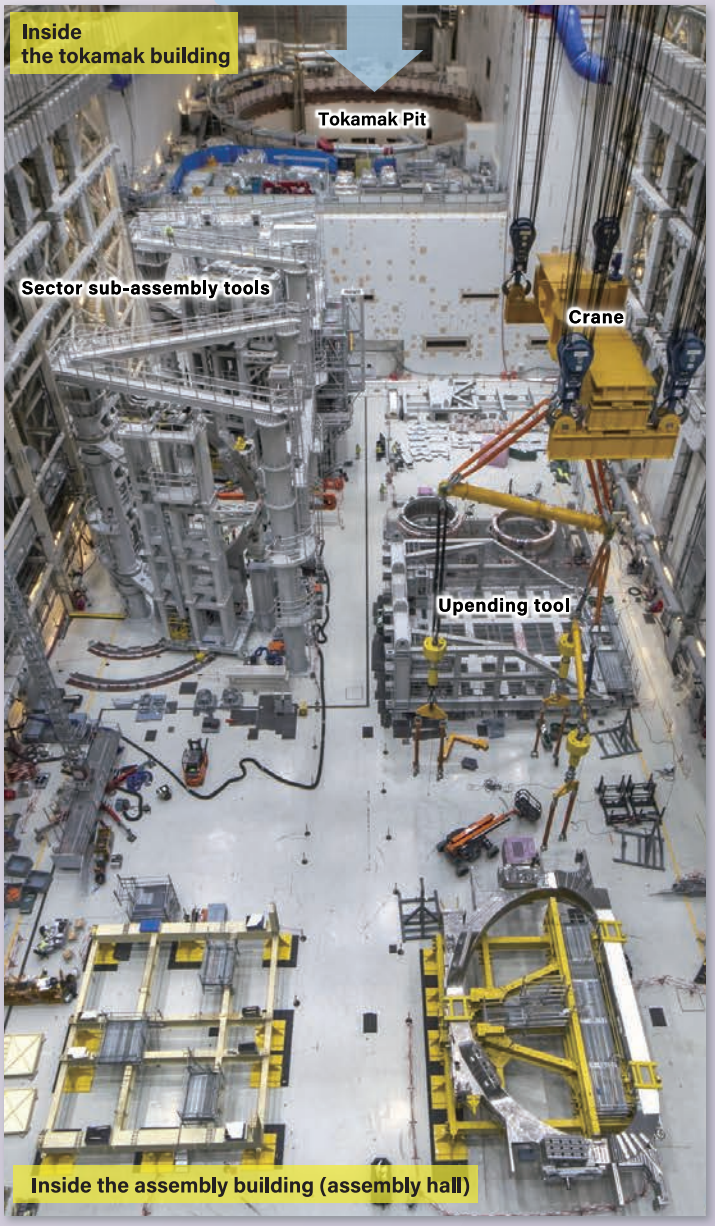
Device	Japan Procurement	Progress
Atmosphere Detritiation System	50%	Final design 50% achieved

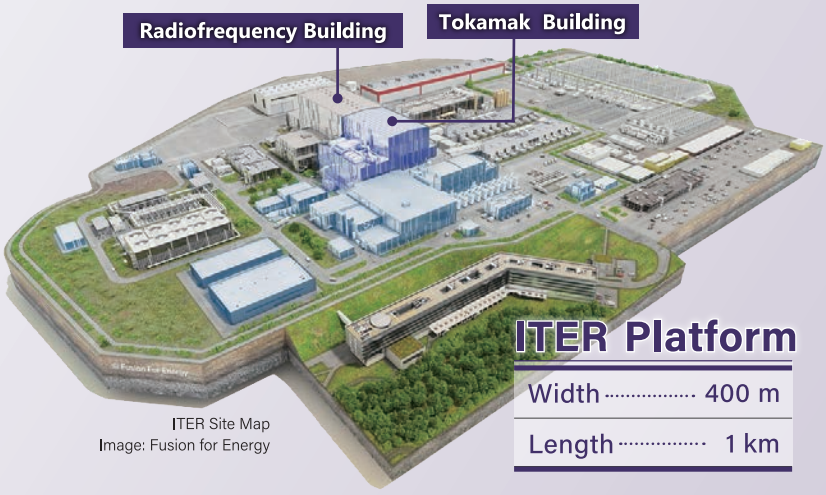
ITER site

ITER is located in Saint-Paul-lez-Durance in southern France, about an hour's drive from Marseille.
Under construction since 2007, several buildings now dot the 42-hectare platform of the vast, 180-hectare ITER site.
The ITER site is home to about 1,000 ITER Organization employees, as well as a sizeable population of engineers and researchers from all over the world, all collaborating to make ITER a reality.

In July 2020, all of the critical components arrived from each ITER Member, marking the official start of machine assembly.


ITER will be built in here





ITER Site Map
Image: Fusion for Energy

ITER Platform

Width	400 m
Length	1 km

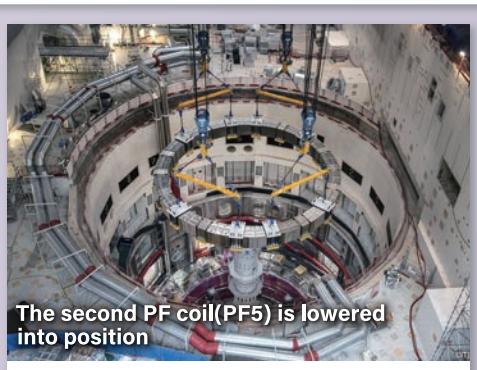
The massive assembly hall (60 m × 97 m × 60 m), an impressive building in its own right, is where the extremely large components are assembled. Standing six storeys high in the assembly hall are two sector sub-assembly tools.

The upending tool is used to raise the 440-tonne vacuum vessel sectors and the 360-tonne TF coils for sector sub-assemblies. during subsector assembly.
Two 750-tonne bridge cranes are installed near the ceiling to transport the sector sub-assemblies to the tokamak pit.

Tokamak Building — Tokamak Pit

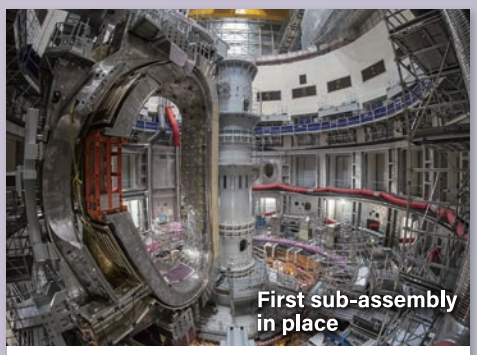
Cryostat base installed

May 2020:
The cryostat base is installed.



The second PF coil(PF5) is lowered into position

September 2021: The second PF coil (PF5, 17 m wide, 350 t) is installed.

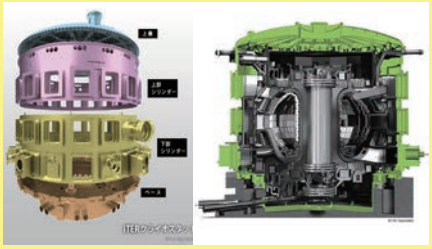


First sub-assembly in place

May 2022:
The first sub-assembly is installed.

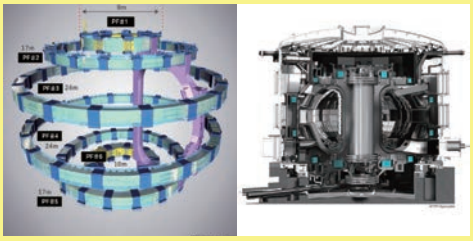
What is a cryostat?

The cryostat provides a high vacuum, ultra-cool environment for the ITER vacuum vessel and the superconducting magnets.



What are poloidal field (PF) coils?

The six poloidal field coils, installed horizontally around the ITER vacuum vessel, will ensure the shape and stability of the super-hot plasma.



Assembly Hall — Sector sub-assembly

A vacuum vessel sector is docked

April 2021:The first vacuum vessel sector (440 t) is positioned in a sector sub-assembly tool.

TF Coil #12 stands vertically

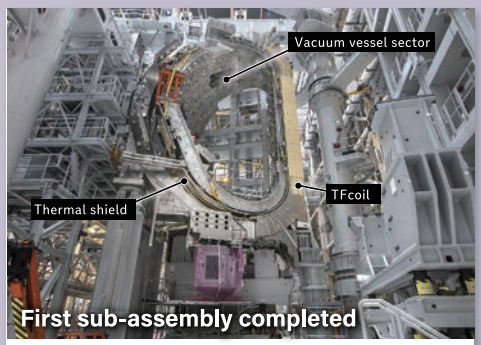
June 2021:
The first TF coil is raised from horizontal to vertical with the upending tool.

Installation of first sector sub-assembly

September 2021:
A second TF coil is installed forming a complete sector sub-assembly.

Vacuum vessel sector thermal shield installation

September 2021:
A thermal shield panel is attached to a vacuum vessel sector.

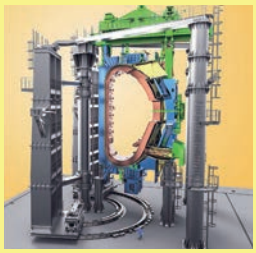


First sub-assembly completed

November 2021:
The first sub-assembly is positioned and installed with millimetre-order tolerances.

What is a sector sub-assembly?

The ITER tokamak is incredibly heavy, so sub-assemblies must be installed in stages. A sub-assembly is composed of two TF coils for each vacuum vessel sector.



A total of nine sub-assemblies will be installed in the tokamak pit, forming a donut-shaped torus.

Please check our website and enable the translation function for English.

Our website hosts a series of resources on fusion, for both the beginner and for those wanting to learn even more.

Stay up to date with daily updates on our social media sites.

QR codes are on the back cover.

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The Quest for Sustainable Energy

Introductory Manga for the ITER Project
"A Small Sun on Earth"
now available on our website!

www.fusion.qst.go.jp/ITER/comic/page1_1.html

Check it Out!!

Nov. 2024