INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR -S & T

NEWS: Scientists have completed the main magnet system for **ITER (International Thermonuclear Experimental Reactor),** with India playing a significant role in building critical infrastructure.

WHAT'S IN THE NEWS?

Global Collaboration on Fusion Research:
The ITER Project is a massive international scientific collaboration involving **over 30 countries**, including major powers such as **India, China, the US, Russia, Japan, South Korea, and the European Union (EU)**.

Location and Scale:
ITER is being constructed on a **180-hectare site in Southern France** and will house the **world's largest tokamak**, a magnetic confinement fusion device.

Scientific Concept Behind ITER

Fusion Process:
Nuclear fusion generates energy by **fusing two light atomic nuclei** (like deuterium and tritium) to form a **heavier nucleus**, releasing large amounts of energy, similar to the process powering the **Sun and stars**.

Difference from Nuclear Fission:
Unlike nuclear fission (which splits heavy atoms), **fusion does not produce long-lived radioactive waste**, making it a **cleaner and safer energy alternative**.

Key Objectives of ITER

Demonstrating Fusion as a Viable Energy Source:
ITER aims to prove that **fusion can be a large-scale, carbon-free and safe power source**, contributing to the fight against climate change.

"Burning Plasma" Milestone:
The reactor is expected to produce **500 MW of energy output** using **50 MW of input energy**, thereby achieving a self-sustaining **burning plasma** — a key milestone for future reactors.

Not a Power Plant:
ITER is **not designed to produce electricity**; it will serve purely as a **research facility** to study the physics and engineering of fusion at an industrial scale.

Cost Sharing Among Member Countries

Europe's Major Share:
The **EU is funding 45%** of ITER's construction cost.

Equal Share by Others:
The remaining six members — **India, China, Japan, South Korea, Russia, and the US** — are each contributing approximately **9%** of the cost.

Equal Access to Research Outcomes:
Despite varying financial contributions, **all members will have full access** to ITER's **research data, technology, and intellectual property**.

Contributions by Participating Nations

United States:
Constructed the **Central Solenoid**, a powerful magnet at the heart of the ITER Tokamak.

Russia:
Supplied a **Poloidal Field magnet**, essential for shaping the plasma.

Europe:
Designed and built **four large Poloidal Field magnets**, key components of the magnetic confinement system.

China:
Supplied **Poloidal Field magnets** and **superconducting Correction Coil magnets**.

Japan:
Manufactured **43 kilometers of Nb_3Sn superconductor strand**, used in ITER's magnetic coils.

South Korea:
Developed **tooling systems** for pre-assembling large-scale components of the reactor.

India's Significant Contributions

Cryostat Design and Manufacturing:
India **designed and built** the **cryostat**, a 30-meter-tall chamber that houses the Tokamak and maintains its ultra-cold operating temperatures.

Cooling Infrastructure:
India contributed **cryogenic systems and cryolines** that help cool superconducting magnets to **-269°C**, essential for maintaining magnetic confinement.

Additional Systems:
India delivered several critical components including **shielding systems, cooling water systems**, and **heating technologies**.

Progress So Far

Completion of Electromagnet System:
ITER has completed its **powerful pulsed superconducting electromagnet system**, weighing nearly **3,000 tonnes**, which will help in the confinement and stabilization of plasma.

Plasma Generation:
This system is capable of heating a hydrogen fuel mix (deuterium and tritium) to **150 million degrees Celsius**, replicating the core conditions of the Sun for initiating nuclear fusion.

Future Outlook

Milestone Timeline:

ITER is projected to begin **scientific operations by 2034**.

The full **Deuterium-Tritium fusion experiments** are expected to start by **2039**.

Promise of Clean, Infinite Energy:
If successful, ITER could demonstrate the potential for **limitless, clean, and safe energy**, addressing long-term global energy demands **without greenhouse gases or hazardous waste**.

Symbol of Global Scientific Unity:
ITER represents **unprecedented international scientific collaboration** for sustainable development, combining the expertise, funding, and innovation of countries across continents.

Comparison: Nuclear Fission vs Nuclear Fusion

Aspect	Nuclear Fission	Nuclear Fusion
Process	Splitting of a heavy nucleus (e.g., Uranium-235)	Fusing of two light nuclei (e.g., Deuterium + Tritium)
Energy Source	Used in current nuclear power plants	Still in experimental stage (e.g., ITER)
Energy Output	High, but limited by fuel and waste issues	Extremely high and potentially limitless
Fuel Availability	Limited (Uranium, Plutonium)	Abundant (Hydrogen isotopes from

Aspect	Nuclear Fission	Nuclear Fusion
		water, lithium)
Radioactive Waste	Significant and long-lived	Minimal and short-lived
Risk of Meltdown	High (e.g., Chernobyl, Fukushima)	Low, as fusion reactions are difficult to sustain
Greenhouse Gas Emissions	Low, but not zero (due to mining, processing)	Near-zero emissions
Current Use	Commercial electricity production	Experimental research stage
Sustainability	Finite fuel supply	Considered highly sustainable

ITER Timeline and Milestones (Infographic Summary)

Year	Milestone / Event
2006	Formal launch of the **ITER Agreement** among 7 members (EU, US, India, China, etc.)
2007–2013	Site preparation and initial construction in **Cadarache, Southern France**
2015–2021	Major manufacturing and delivery of components by member nations
2020	**Start of Assembly Phase** — Integration of cryostat, magnets, and core components
2023	Completion of **pulsed superconducting electromagnet system**
2024–2033	Continued integration, vacuum vessel assembly, system testing
2034	Planned start of **scientific operations** (non-fusion plasma experiments)
2039	Begin **Deuterium-Tritium fusion operations** to create burning plasma
Post-2040	Research outcomes to guide design of **DEMO** — a prototype commercial fusion reactor

Source: https://www.thehindu.com/sci-tech/science/worlds-largest-fusion-project-reaches-construction-milestone-with-indias-help/article69521130.ece#:~:text=unlocking%20fusion%20energy.-,India%20has%20designed%20and%20manufactured%20the%20cryostat%2C%20an%20enormous%2030,the%20temperature%20needed%20for%20superconductivity.