Q5

# The fusion energy programme in India has steadily evolved over the past few decades. Mention India's contributions to the international fusion energy project - International Thermonuclear Experimental Reactor (ITER). What will be the implications of the success of this project for the future of global energy?

UPSC Civil Services Mains 2025 · GS III · 10 marks · Infrastructure

Infrastructure: Energy, Ports, Roads, Airports, Railways etc.

## Core demand of the question

- **Sketch India's fusion path and ITER role:** in-kind hardware, science, human capital
- **State what ITER success would mean for global energy:** baseload low-carbon fire, not a 2030 plug

## Revision summary

Fusion joins light nuclei and could, in theory, give large low-carbon power without a fission-style chain reaction.

ITER in France is the global experiment; India is a member supplying about a tenth of in-kind components such as the cryostat and cooling systems.

Indian tokamaks and the Institute for Plasma Research built the domestic base.

ITER success would prove the physics, not deliver cheap power in 2030.

The climate implication is a possible later baseload, beside renewables that are needed now.

## Introduction

**Fusion is the sun's physics: light nuclei join and release energy. A power station that did that without a chain-reaction bomb would change the century. It does not exist yet. ITER**, in France, is the world's largest experiment to prove a burning plasma at power-plant scale. India is not a spectator. It is a **full member** that ships hardware and people.

## Body

## India's path and ITER contribution

- **India's fusion work sits at the** Institute for Plasma Research **and related labs:** tokamaks such as **Aditya** and **SST-1**, materials, and cryogenics. Joining **ITER** (with the EU, US, Russia, China, Japan, Korea) committed India to about **nine per cent** of the in-kind load. Indian industry and labs have supplied **cryostats, cooling water, vessel in-wall shields, diagnostics and power supplies** - heavy, precise steel and science, not a flag in a photo. Young engineers learn a project whose delays are famous and whose skill is rare.

- **That is the contribution: components, contracts, and a generation that has seen a global machine**.

### If ITER succeeds

Success would mean a **sustained, controlled burning plasma** with a gain (Q) that shows the physics works. It would **not** mean a cheap bill in 2030. A commercial plant would still need materials that survive neutron rain, a tritium cycle, and a cost that beats fission and renewables-plus-storage. The implication for **global energy** is a possible **firm, low-carbon baseload** that is not a fossil flame and not a fission waste stream of the same kind. For climate, that is a **late-century option**, complementary to solar and wind that must be built **now**.

For India, success would mean a seat in the **first commercial designs**, energy security in a world still hungry for always-on power, and a scientific prestige that is not only software. Failure or endless delay would still leave the **industrial learning**. Fusion is a long bet. ITER is how India stays on the board.

### Flow diagram

Indian tokamaks Indian tokamaks IPR -> ITER

ITER -> Cryostat shield cooling

ITER -> Burning plasma proof

Burning plasma proof -> Future baseload option

### Conclusion

India contributes hardware, cryogenics and people to ITER as a full partner. If ITER proves a burning plasma, the world gains a path to firm low-carbon power decades out. It is not a substitute for the solar and storage India must install this decade.

### Facts & figures

**ITER members**
The EU, China, India, Japan, Korea, Russia and the United States share the project in southern France.

**Indian in-kind share**
About nine per cent of ITER's hardware contribution, including the cryostat, a signature Indian delivery.

**Q value**
The ratio of fusion power to heating power; ITER aims to show a burning plasma with Q well above one.