



LAST MINUTE PRELIMS RECKONER 2025

SCIENCE & TECHNOLOGY

NUCLEAR ENERGY IN INDIA

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NUCLEAR REACTION:

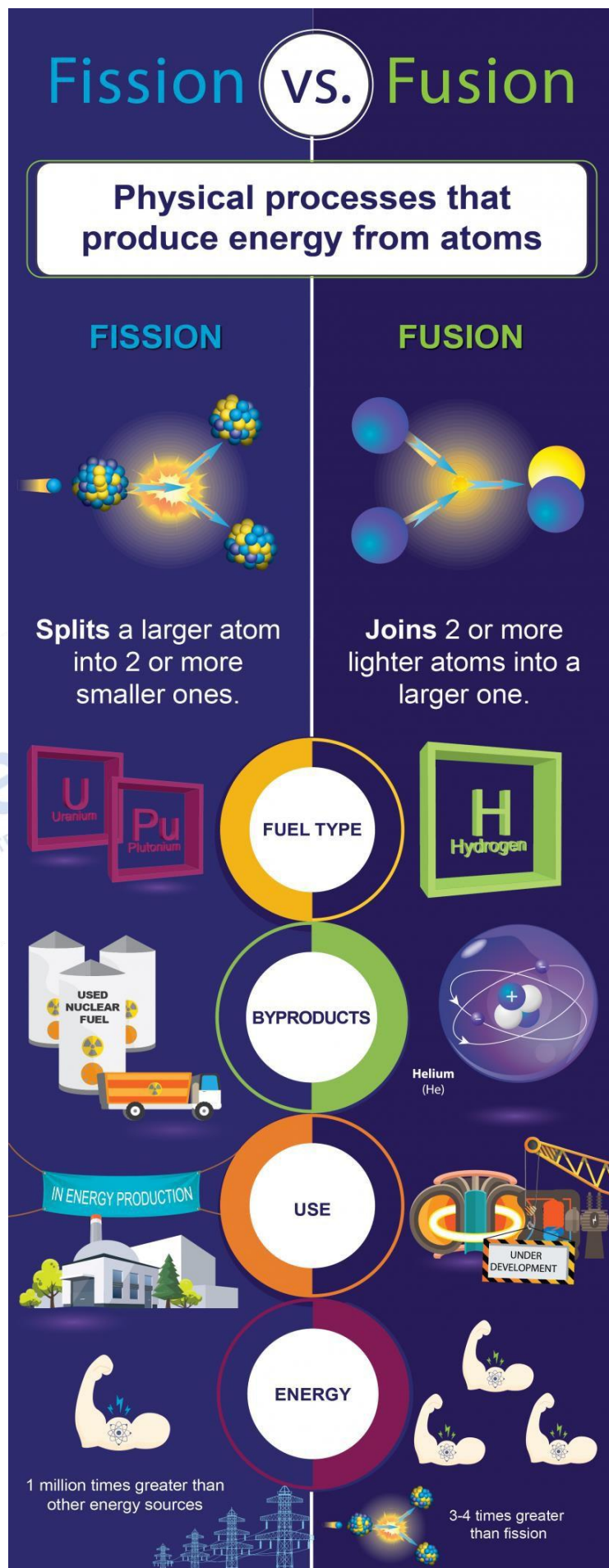
- ✓ In nuclear physics, a nuclear reaction is a process in which two nuclei or nuclear particles collide, to produce different products than the initial particles.
- ✓ The bombarding particle may be an **alpha particle**, a **gamma-ray photon**, a **neutron**, a **proton**, or a **heavy ion**.
- ✓ **Fission and fusion** are nuclear processes by which atoms are altered to create energy.

FISSION REACTION:

- ✓ Fission occurs when a neutron slams into a larger atom, forcing it to excite and split into two smaller atoms—also known as **fission products**.
- ✓ When each atom splits, a tremendous **amount of energy is released**.
- ✓ Additional neutrons are also released that can initiate a chain reaction.

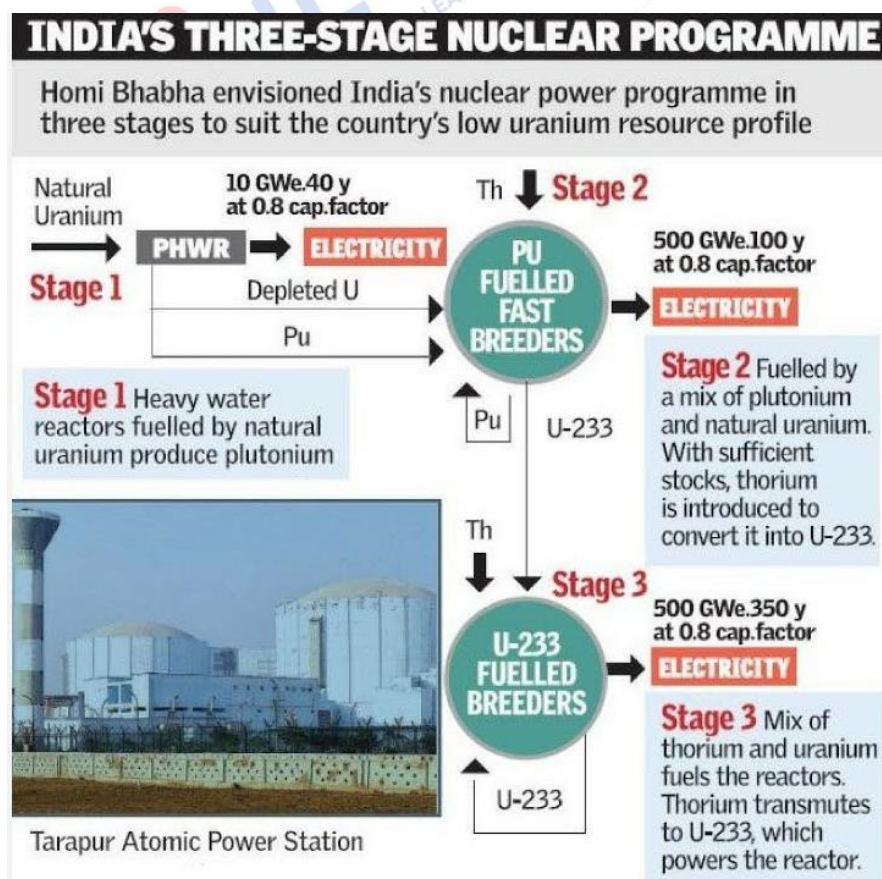
FUSION REACTION:

- ✓ Nuclear fusion refers to the **union of atomic nuclei to form heavier nuclei** resulting in the release of enormous amounts of energy.
- ✓ Fusion takes place when two low-mass isotopes, typically isotopes of hydrogen, unite under conditions of extreme pressure and temperature.



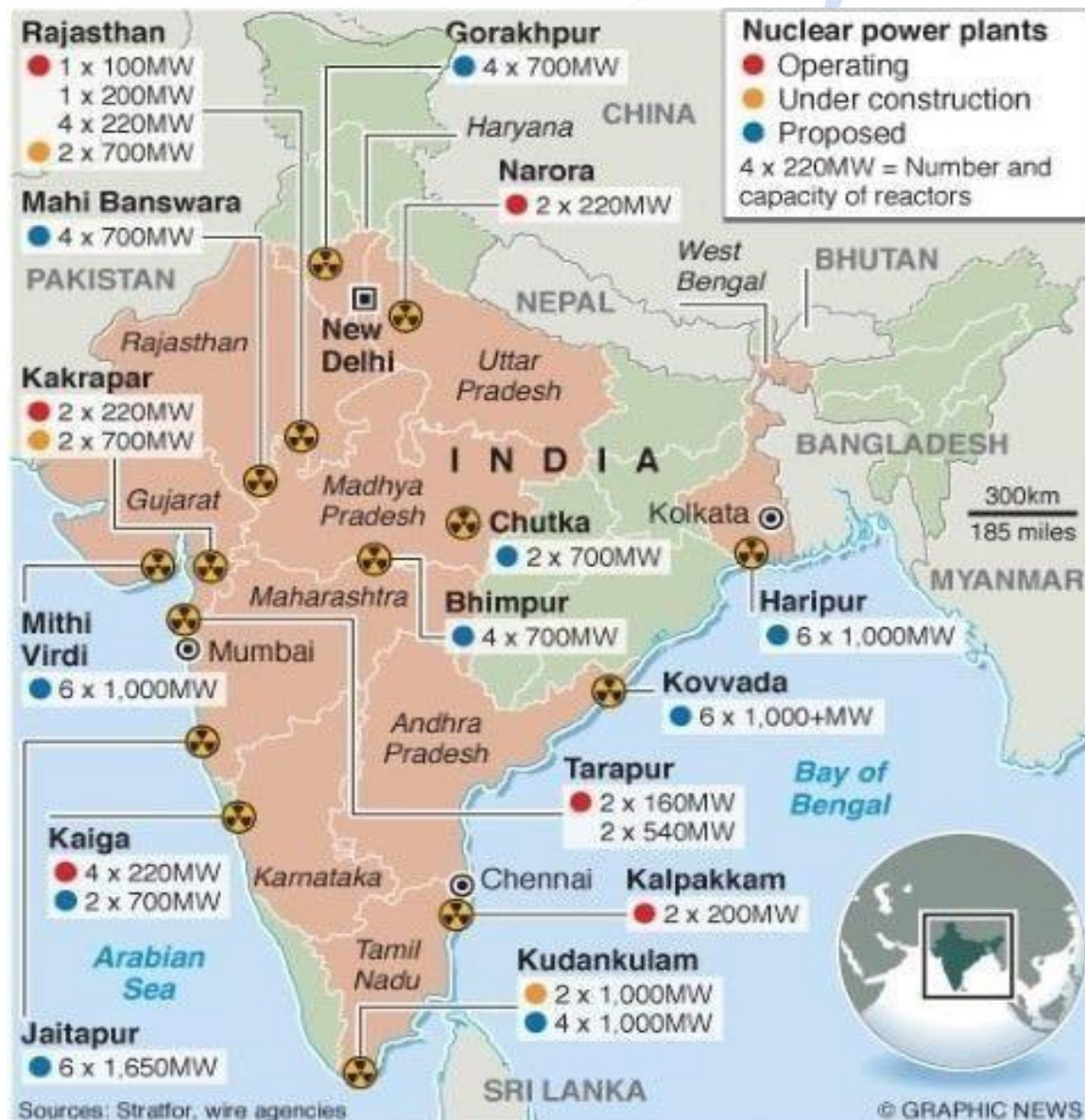
INDIA'S THREE-STAGE NUCLEAR POWER PROGRAM:

- ✓ India's three-stage closed fuel cycle nuclear power programme was formulated by **Dr. Homi Bhabha** in the 1950s to secure the country's long-term energy independence.
- ✓ The emphasis of the program is to **utilize the large thorium deposits** present in the country.
- ✓ **Stage 1: Pressurized Heavy Water Reactors (PHWR)**
 - PHWRs use natural Uranium to **produce electricity while generating plutonium-239** as by-product. This stage has been operational since 1973.
 - The Pu-239 generated is key for Stage 2.
 - Most recently, in December 2023, the **4th unit of the Kakrapar Atomic Power Plant in Gujarat attained criticality.**
 - **Criticality refers to the initiation of a self-sustaining nuclear reaction** that will lead to power generation – i.e., the **nuclear plant is operating safely.**
- ✓ **Stage 2: Fast Breeder Reactors (FBRs)**
 - FBRs would use a mixture of Plutonium and reprocessed spent Uranium from the first stage, to produce energy and **more Plutonium (hence the name 'breeder')**.
 - A 500 MWe prototype fast breeder nuclear reactor, named **Bhavini**, is presently being constructed at the Madras Atomic Power Station in **Kalpakkam**.
 - After 3-4 decades of operation, the FBRs would have produced enough Plutonium for use in the 'third stage'.
 - In March 2024, **core loading began at the Bhavini reactor.**
 - **Core loading is the first step towards attaining criticality.** It refers to the **placing of nuclear fuel inside the reactor**
- ✓ **Stage 3: Thorium-based reactors**
 - In the third stage, **thorium is used along with plutonium** for power generation.



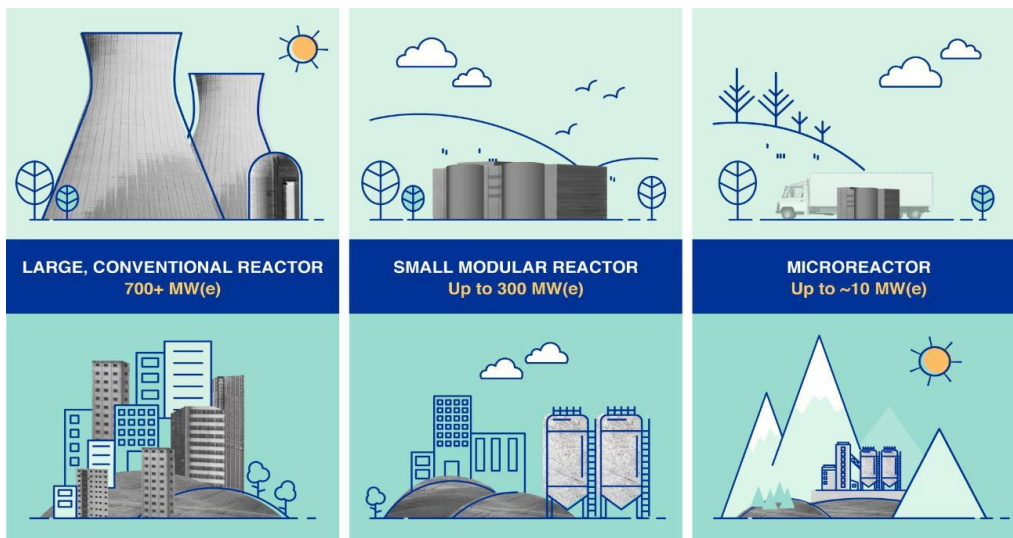
NUCLEAR POWER IN INDIA:

- ✓ India aims to increase nuclear power capacity **from 7.4 GW in 2022 to 100 GW by 2047.**
- ✓ Nuclear energy and hydrogen, were identified as **key to India's Long Term Low Emission Development Strategy (LT-LEDS)** which was presented at UNFCCC COP 27 in 2022.
- ✓ Long-term goal is to raise nuclear power to **10% of India's energy mix by 2035.**
- ✓ Currently, **all of India's nuclear power plants are operated by the govt.** – in line with the provisions of the Atomic Energy Act, 1961 and Civil Liability for Nuclear Damage Act, 2010.
- ✓ In Feb 2024, **Union govt. decided to invite domestic private companies to invest approx. \$26 billion** in India's nuclear power sector, marking a significant shift in its energy policy.
- ✓ The govt is negotiating with leading firms such as Reliance Industries, Tata Power, Adani Power, and Vedanta Ltd. for investments of about \$5.3 billion each in nuclear energy sector.
 - The govt aims to add **11 GW of new nuclear power generation capacity by 2040** through this investment.
- ✓ Presently, the FDI policy of India **prohibits foreign investment in atomic energy sector.**
- ✓ In contrast, there is **no restriction on FDI in the industry for manufacturing nuclear equipment and parts for nuclear power plants** and other related facilities.



SMALL MODULAR REACTORS (SMRs)

- ✓ They are advanced nuclear reactors with a **capacity of up to 300 MW per unit**.
- ✓ Offers advantages such as **simplicity, safety, and cost-effectiveness**.
- ✓ SMRs can be **factory-made and transported to a site for installation**.
- ✓ SMRs are economical and time-efficient - unlike traditional reactors that require refuelling every 1-2 years, **SMRs only need refuelling every 3-7 years**.
- ✓ Niti Aayog's suggestions for SMRs include:
 - Encouraging private sector participation through PPPs.
 - Implement comprehensive regulatory changes to ensure safety standards and monitoring.
 - Modify foreign investment policies to attract FDI for SMR development in India.



NUCLEAR ENERGY MISSION - ANNOUNCED IN 2025 UNION BUDGET

Details	<ul style="list-style-type: none"> Aims to accelerate nuclear power capacity towards the target of 100 GW by 2047. It focuses on indigenous Bharat Small Reactors (BSRs), and policy reforms to attract private and foreign investment in nuclear energy. It is aiming to develop at least 5 indigenous Small Modular Reactors (SMRs by 2033).
Highlights	<ul style="list-style-type: none"> Public-Private Collaboration for setting up Bharat Small Reactors (BSRs) and advanced nuclear technologies. Amendments to Atomic Energy Act, 1962 to allow private sector participation. Amendments to Civil Liability for Nuclear Damage Act, 2010 to attract foreign investment. Deployment of BSRs (220 MWe) and SMRs (30-300 MWe) to replace coal plants and power remote regions.