India’s third home-built 700 MWe nuclear reactor achieves criticality

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Context:

The nuclear power reactor that achieved criticalityis the first of a new series of Pressurised Heavy Water Reactors (PHWRs) to be built at**Rajasthan Atomic Power Project in Rawatbhata** (**RAPP-7)**.

About

- **700 MWe units are the largest indigenous nuclear power reactors**built by the **Nuclear Power Corporation of India Limited(NPCIL),**a public sector undertaking of the **Department of Atomic Energy.**
- These**reactors are pressurized heavy water reactors (PHWRs)**, which**use natural uranium as fuel and heavy water as coolant and moderator.**
- The reactor achieved criticality after meeting the specified conditions of the**Atomic Energy Regulatory Board (AERB),India’s nuclear safety regulator.**

Nuclear Criticality

- In nuclear reactor operation, criticality is the **self-sustaining state of a nuclear chain reaction**.
- When there is a **perfect balance between neutron production and loss rates**, the nuclear system is considered critical.
- During reactor startup, the **neutron population is gradually increased in a controlled manner**, ensuring **more neutrons are produced than lost**.
- When the desired power level is achieved, the nuclear reactor is placed into a **critical configuration**.
- **Subcritical** describes a nuclear system where **neutron loss exceeds neutron production**.
- **Supercritical** describes a nuclear system where **neutron production exceeds neutron loss**.

Key Highlights of India’s Nuclear Power Sector:

Current Energy Landscape:

- India's **total installed power capacity presently stands at 428 GW**, expected to **double to 810 GW by 2030**.
- Nuclear power **contributes approx 3% to India’s energy mix.**

Current Nuclear Power Scenario:

- India operates **24 reactors with a total capacity of 8,180 MWe**, contributing approximately **3% to the nation's energy mix**.
- **Eight additional units**, of which **RAPP-7 is one**, are under construction, **adding 6,800 MWe**.

- This includes a **Prototype Fast Breeder Reactor (PFBR)** and **four Pressurized Water Reactors (PWRs)** based on **Russian technology**.
- The government has also sanctioned **ten indigenous Pressurized Heavy Water Reactors (PHWRs)** of **700 MW** each, aiming for significant capacity expansion by 2031.
- Plans for **10 more reactors are in the pre-project phase** to be progressively completed by 2031-32.

Pressurized Heavy-Water Reactor (PHWR)

- Uses**heavy water (deuterium oxide D2O)**as its coolant and neutron moderator.
- The heavy water coolant is kept under pressure, allowing it to be heated to higher temperatures without boiling, much as in a pressurized water reactor.
- While heavy water is significantly**more expensive**than ordinary light water, it creates**greatly enhanced neutron economy**, allowing the reactor to**operate without fuel-enrichment facilities**(offsetting the additional expense of the heavy water) and enhancing the ability of the reactor to make use of alternate fuel cycles.

Advantages of PHWR

- PHWRs can**use natural uranium, reducing the need for fuel enrichment facilities**.
- Unlike other reactors,**PHWRs can be refueled without shutting down.**
- PHWRs have the**potential to use different types of fuel,** including **mixed oxide (MOX) fuel** and **thorium**, which is abundant in India.

Disadvantages

- **Heavy water is expensive**to produce and maintain due to its isotopic composition.
- The use of pressure tubes adds**complexity to the reactor's design**and increases maintenance needs.

PHWRs are predominantly used in**Canada (CANDU reactors)**and**India**.

Key Players and Regulatory Environment:

Key Players: The**Department of Atomic Energy (DAE),**the**Nuclear Power Corporation of India (NPCIL),**and the**National Thermal Power Corporation (NTPC)**are the key organizations that play a pivotal role in the nuclear energy sector in India.

All three are **under the control of the Union government**.

NPCIL is the **owner and operator of all nuclear power plants** (except the**PFBR variants,**owned by The**Indira Gandhi Centre for Atomic Research (IGCAR), DEA)**and the primary contact for all nuclear business in India.

NTPC is a major producer of electricity from coal and accounts for 70GW capacityand is seeking to adopt nuclear reactors as part of its strategy to phase out old coal plants.

Regulatory Oversight:

- The**Atomic Energy Regulatory Board (AERB)**oversees**nuclear safety and regulatory processes**, including site selection, construction, operation, and decommissioning.

AERB's responsibilities extend to nuclear applications in various sectors.

- **Nuclear Liability and Insurance:**

- India ratified the Convention on**Supplementary Compensation for Nuclear Damage (CSC) in 2016,** establishing a global compensation regime for nuclear accidents.
- The**Civil Liability for Nuclear Damage Act (CLND), 2010,**sets liabilities for operators and mandates insurance to cover potential damages.
- The**Indian Nuclear Insurance Pool (INIP),**backed by**General Insurance Corporation of India (GIC-Re)** and other insurers, provides USD 15 billion in coverage to protect suppliers against liability claims.