AERB Grants 5-Year Operation Licence to India’s First Indigenous 700 MWe PHWRs at Kakrapar

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Recent Developments:

- **Atomic Energy Regulatory Board (AERB)** has granted a **five-year Licence for Operation** to **Nuclear Power Corporation of India Limited (NPCIL)** for **Kakrapar Atomic Power Station (KAPS)-3 & 4** in **Gujarat**, after completing rigorous multi-tiered safety reviews covering design, construction, commissioning, and full-power operation.
- **KAPS-3** achieved **full-power commissioning in August 2023**, while **KAPS-4** reached full-power operation in **August 2024** before receiving the regular operating licence.
- **KAPS-3 & 4** are **India’s first indigenously designed 700 MWe Pressurised Heavy Water Reactors (PHWRs)**, representing an upgraded design evolved from the earlier **540 MWe PHWR**.
- The approval strengthens **NPCIL’s fleet-mode programme** for construction of additional **700 MWe PHWRs** across the country.

India’s Nuclear Power Programme:

Evolution of India's Nuclear Programme:

- India's civilian nuclear programme began with the establishment of the **Atomic Energy Commission (AEC)** in **1948**.
- **Apsara**, Asia's first research reactor, became operational in **1956** at **Bhabha Atomic Research Centre (BARC), Trombay**.
- India commissioned its first commercial nuclear power plant at **Tarapur** in **1969**, becoming the **second Asian country** after Japan to establish a nuclear power station.
- During the **1950s and 1960s**, India developed a strong nuclear research ecosystem with international technological cooperation.
- **Dr. Homi J. Bhabha** conceptualised India's **Three-Stage Nuclear Power Programme**, while **Dr. Vikram Sarabhai** supported its long-term implementation for achieving energy security.

Objectives of the Three-Stage Nuclear Programme:

- The programme aims to achieve **long-term energy security** by maximising the utilisation of India's limited **uranium** reserves and abundant **thorium** resources.
- The strategy gradually shifts from **natural uranium** to **plutonium** and finally to **thorium-based uranium-233 (U-233)** fuel.

Three-Stage Nuclear Power Programme:

Stage-I: Pressurised Heavy Water Reactors (PHWRs):

- **PHWRs** use **natural uranium** as fuel and **heavy water (Deuterium Oxide – D?O)** as both the **moderator** and **coolant**.

- Electricity generation in PHWRs also produces **Plutonium-239 (Pu-239)**, which is recovered through **spent fuel reprocessing**.
- India's PHWR programme started with **Rajasthan Atomic Power Station (RAPS-1)** during the late **1960s**, based on Canadian reactor technology.
- India presently operates **15 PHWRs of 220 MWe**, **2 PHWRs of 540 MWe**, and has commissioned indigenous **700 MWe PHWRs** under the next-generation fleet programme.
- Imported **Light Water Reactors (LWRs)** supplement India's overall nuclear power capacity.

Stage-II: Fast Breeder Reactors (FBRs):

- **Fast Breeder Reactors (FBRs)** primarily use **plutonium-based fuel** generated during Stage-I.
- FBRs produce **more fissile material than they consume** by converting **fertile thorium** into **Uranium-233 (U-233)**.
- Efficient **spent fuel reprocessing** is essential for recycling plutonium and sustaining the closed nuclear fuel cycle.
- India's flagship **Prototype Fast Breeder Reactor (PFBR-500 MWe)** at **Kalpakkam** has achieved important commissioning milestones, including sodium system commissioning and core loading.

Stage-III: Thorium-Based Nuclear Programme:

- The final stage is based on the **Thorium–Uranium-233 (Th-U233) fuel cycle**.
- **Uranium-233**, produced during Stage-II, becomes the principal fuel for advanced reactors.
- The proposed **Advanced Heavy Water Reactor (AHWR)** has been designed to utilise thorium efficiently.
- **Molten Salt Reactors (MSRs)** are also being explored as a future option for thorium utilisation.

Pressurised Heavy Water Reactor (PHWR):

Key Features:

- **PHWR** is a nuclear reactor that uses **heavy water** as both **moderator** and **coolant**.
- It generally uses **natural uranium** as reactor fuel, reducing dependence on uranium enrichment facilities.
- PHWR technology supports **online refuelling**, enabling uninterrupted electricity generation.
- Indigenous PHWR technology has significantly improved India's self-reliance in nuclear reactor design and manufacturing.
- The **700 MWe PHWR** incorporates enhanced **passive safety systems**, improved thermal efficiency, and better operational reliability than earlier designs.

Government Initiatives to Expand Nuclear Capacity:

Capacity Expansion:

- India plans to increase installed nuclear power capacity from **8,180 MW** to **22,480 MW** by **2031–32**.
- Ten reactors with a combined capacity of about **8,000 MW** are under construction across **Gujarat, Rajasthan, Tamil Nadu, Haryana, Karnataka, and Madhya Pradesh**.
- Preparatory activities have commenced for another **ten reactors**, targeted for phased completion by **2031–32**.
- India has approved the establishment of **6 × 1208 MW** nuclear reactors at **Kovvada, Andhra Pradesh**, in cooperation with the **United States**.
- The **Union Budget 2025–26** announced a long-term vision of achieving **100 GW nuclear power capacity by 2047**, making nuclear energy a major component of India's clean energy transition.

Recent Developments in India’s Nuclear Sector:

Major Developments:

- A significant **uranium deposit** discovered near **Jaduguda Mines** is expected to extend the operational life of India's oldest uranium mine by more than **50 years**.
- **KAPS-3 & KAPS-4** have become the country's first commercially operational indigenous **700 MWe PHWRs**.
- India's **PFBR-500** has crossed important commissioning milestones, advancing the country's **closed nuclear fuel cycle**.
- **NPCIL** and **NTPC** have established the joint venture **ASHVINI** to develop, own, and operate future nuclear power plants.
- The proposed **Mahi-Banswara Project** in Rajasthan will consist of **4 × 700 MWe PHWRs** under the joint venture.

Atomic Energy Regulatory Board (AERB):

About AERB:

- **AERB** was constituted on **15 November 1983** under the provisions of the **Atomic Energy Act, 1962**.
- It serves as India's **national nuclear safety regulator** responsible for ensuring the safe use of nuclear energy and radiation technologies.
- Its regulatory authority is derived from the **Atomic Energy Act, 1962**, associated rules, and the **Environment (Protection) Act, 1986**.
- AERB regulates the complete lifecycle of nuclear facilities, including **site selection, design, construction, commissioning, operation, decommissioning, and radioactive waste management**.
- It also establishes **radiation safety standards**, conducts inspections, grants licences, and enforces compliance with national and international safety requirements.

Significance of Indigenous 700 MWe PHWRs:

Strategic Importance:

- They strengthen **Atmanirbhar Bharat** in advanced nuclear reactor technology.
- They reduce dependence on imported reactor designs and critical nuclear equipment.
- They support **energy security** through reliable **baseload electricity generation**.
- They contribute to India's **Net Zero** commitments by providing **low-carbon electricity**.
- Fleet-mode construction lowers project cost, standardises manufacturing, and shortens construction timelines.
- Indigenous PHWRs create opportunities for greater participation of Indian industries in the nuclear supply chain.

Value Addition for UPSC:

Important Facts:

- **Fuel of PHWR:** Natural Uranium.
- **Moderator & Coolant of PHWR:** Heavy Water (**D?O**).
- **Fuel of Stage-II:** Plutonium.
- **Fuel of Stage-III:** Uranium-233 produced from Thorium.
- **India's Nuclear Programme Architect: Dr. Homi J. Bhabha**.
- **Supporting Scientist: Dr. Vikram Sarabhai**.
- **First Research Reactor: Apsara (1956)**.
- **First Commercial Nuclear Power Plant: Tarapur Atomic Power Station (1969)**.
- **First Indigenous 700 MWe PHWRs: Kakrapar Units 3 & 4, Gujarat**.
- **Target Nuclear Capacity: 22.48 GW by 2031–32** and **100 GW by 2047**