

## India's first indigenous Fast Breeder Reactor

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Science and Technology

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The **Core Loading** of India's first indigenous Fast Breeder Reactor was commenced recently at Madras Atomic Power Station in **Kalpakkam, Tamil Nadu**.



[Ref- Times of India]

### **What is Prototype fast breeder reactor (PFBR)?**

- The PFBR is a machine that produces more nuclear fuel than it consumes.
- The operationalization of the PFBR will mark the start of stage II of [India's nuclear power](#) program.
- This three-stage programme was designed by [Dr. Homi J. Bhabha](#) based on power needs and huge [thorium reserves in India](#).

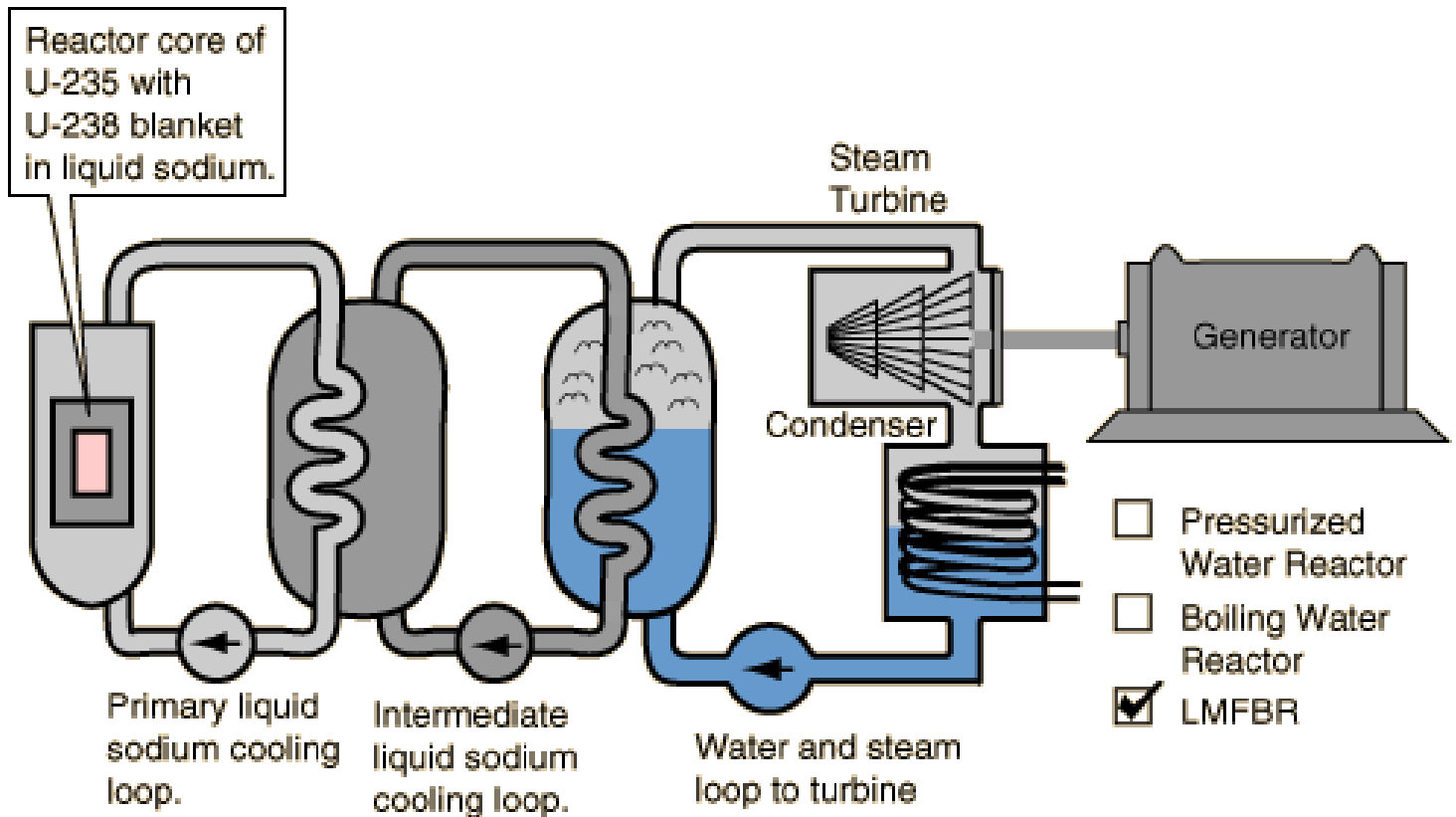
### **Stages of India's Nuclear program:**

- India used **pressurized heavy water reactors (PHWRs)** and **natural uranium-238 (U-238)**, which contain minuscule amounts of U-235, as the **fissile material**.
- The **heavy water in PHWR** are water molecules containing the deuterium isotope of hydrogen, slows neutrons released by one fission reaction.
- It can be **captured by other U-238 and U-235** nuclei and cause new fission.
- The heavy water is pressurized to keep it from boiling and produces **plutonium-239 (Pu-239)** and energy.
- Only U-235 can sustain a chain reaction but it is consumed fully in stage I.
- In **stage II**, India will use **Pu-239 together with U-238** in the PFBR to produce energy, U-233, and more Pu-239.
- The **Department of Atomic Energy (DAE)** set up a special-purpose vehicle in 2003 called **Bharatiya Nabhikiya Vidyut Nigam, Ltd. (BHAVINI)** to implement stage II.
- In stage III, Pu-239 will be combined with thorium-232 (Th-232) in reactors to produce energy and U-233.
- The three stages are expected to allow the country complete **self-sufficiency in nuclear energy**.

### **Prototype Fast Breeder Reactors:**

- Fast breeder reactors employ fast neutrons that **do not slow down**, allowing them to efficiently **trigger specific fission reactions**.

- The PFBR, a fast breeder reactor, is designed to produce more Pu-239 than it consumes, thereby breeding additional fissile material for sustained energy production.
- The PFBR utilizes **liquid sodium**, a highly reactive substance, as a coolant in two separate circuits.
- In the **primary circuit**, sodium coolant enters the reactor core, **absorbs heat** and radioactivity, and **exits to transfer heat** to the secondary circuit.
- Heat is transferred to generators in the **secondary circuit to produce electricity**, while the liquid sodium is recirculated back to the primary circuit.



[Ref- Energy Education]

### Challenges and Realities:

- Despite **theoretical calculations** and mock-up tests, the PFBR has faced challenges in its **operationalization**.
- Issues such as **delayed preheating** of the reactor vessel, underscore the complexities involved in translating theoretical designs into practical realities.
- Overcoming such challenges requires **rigorous testing**, continued research, and adaptive engineering to ensure the **safe and efficient operation** of breeder reactors.
- Breeder reactors hold promise for **enhancing nuclear energy** sustainability by utilizing abundant nuclear fuel resources more efficiently.
- Continued advancements in **breeder reactor technology**, and **proactive problem-solving**, can counter global energy needs.

### About Kalpakkam Power station:

- Kalpakkam is known for its nuclear plants and affiliated research installations.
- These include the Madras Atomic Power Station (**MAPS**), a nuclear power plant, the Indira Gandhi Centre for Atomic Research (**IGCAR**), and the **Bhabha Atomic Research Centre (BARC)**.
- It is a comprehensive **nuclear power production, fuel reprocessing, and waste treatment** facility that includes plutonium fuel fabrication for **fast breeder reactors (FBRs)**.