

Fast Breeder Reactor and Criticality - Kalpakkam Nuclear Milestone

April 7, 2026 • vajiramandravi.com



Fast Breeder Reactor Latest News

- India's Prototype Fast Breeder Reactor (PFBR) at Kalpakkam has achieved criticality, marking a key milestone in the nuclear programme.

About Fast Breeder Reactor

- A Fast Breeder Reactor (FBR) is a type of nuclear reactor that generates more fissile material than it consumes.
- Unlike conventional reactors, which use thermal (slow) neutrons, **FBRs use fast neutrons to sustain nuclear fission**. This allows efficient utilisation of fuel and enhances energy output.
- FBRs typically use plutonium-based fuel, often in the form of Mixed Oxide (MOX), along with fertile materials such as uranium-238. These fertile materials are converted into fissile material (like plutonium-239) during reactor operation.

- A key feature of FBRs is the “breeding” process. In this process, **non-fissile material is transformed into fissile material through neutron absorption**, thereby creating additional fuel.
- FBRs are crucial for countries like India that have limited uranium reserves but abundant thorium resources.
- They form the second stage of India’s three-stage nuclear programme, enabling the transition toward thorium-based energy systems.

Significance of Fast Breeder Reactors

- Fast breeder reactors play a critical role in ensuring long-term energy security.
- They significantly improve fuel efficiency by extracting more energy from available uranium resources.
- They also reduce nuclear waste by utilising materials that would otherwise remain unused.
- In India’s context, FBRs are essential for converting thorium into uranium-233, which is vital for the third stage of the nuclear programme.

Criticality in Nuclear Reactors

- Criticality refers to the **state in which a nuclear reactor achieves a self-sustaining chain reaction**.
- At this stage, each fission event produces enough neutrons to sustain further fission reactions without external intervention.
- Criticality is a crucial milestone in reactor commissioning. It indicates that the reactor core is functioning as designed and is ready to move toward power generation.
- There are three states associated with criticality:
 - **Subcritical state**, where the reaction dies out over time.
 - **Critical state**, where the reaction is stable and self-sustaining.
 - **Supercritical state**, where the reaction increases rapidly.
- Achieving controlled criticality is essential for the safe and efficient operation of nuclear reactors.

News Summary

- India’s 500 MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam in Tamil Nadu has attained criticality, marking a defining step in the country’s nuclear energy programme.
- The reactor is located at the Indira Gandhi Centre for Atomic Research and is operated by **Bharatiya Nabhikiya Vidyut Nigam Limited** (BHAVINI), a public sector enterprise under the Department of Atomic Energy.
- The PFBR is a sodium-cooled, pool-type fast breeder reactor that uses **mixed oxide (MOX) fuel** consisting of uranium-238 and plutonium-239. It is designed to generate more fissile material than it consumes, thereby enhancing fuel sustainability.
- Achieving criticality means that the reactor has initiated a self-sustaining nuclear fission chain reaction, indicating readiness for eventual power generation.
- The project is a key component of **India’s three-stage nuclear programme**.
 - In the first stage, Pressurised Heavy Water Reactors (PHWRs) produce plutonium.
 - In the second stage, fast breeder reactors like PFBR use this plutonium to generate additional fissile material.

- The third stage aims to use thorium to produce uranium-233 for long-term energy security.
- India is now among a select group of countries possessing advanced fast breeder reactor technology, with Russia being the only other nation operating commercial-scale FBRs.
- The reactor also incorporates important safety features such as a **negative void coefficient**, which reduces reaction rates in case of overheating, enhancing operational safety.
- Overall, the achievement of criticality at Kalpakkam marks a significant step toward India's goal of developing a closed nuclear fuel cycle and reducing dependence on imported uranium.

Source: TH | IE

Source: <https://vajiramandravi.com/current-affairs/kalpakkam-fast-breeder-reactor/>

© Vajiram & Ravi. For personal use only.