India takes second leap towards energy security

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New Delhi: A nuclear reactor two decades in the making at the coastal nuclear complex of Kalpakkam, 70km from Chennai, achieved a self-sustaining chain reaction on Monday, marking India's entry into the second stage of a long-planned three-stage nuclear energy strategy.

The 500MW Prototype Fast Breeder Reactor (PFBR), designed to produce more nuclear fuel while it generates power, "successfully attained first criticality" — a controlled nuclear fission chain reaction — at 8.25pm on Monday, India's Department of Atomic Energy (DAE) said on Tuesday.

Three generations of physicists and engineers at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, designed the PFBR, which was built by the public sector Bharatiya Nabhikiya Vidyut Nigam (Bhavini) after clearance by the Atomic Energy Regulatory Board following a detailed safety review of plant systems.

Scientists have been working on the design of fast breeder reactors at least since 1980s while construction on the PFBR began in 2004.

Inside the reactor, plutonium atoms get split, releasing heat and neutrons that sustain the reaction and generate power, while a blanket of uranium surrounding the core gets converted into more plutonium fuel, a process key to breeder technology.

Fast breeder technology is a critical bridge between India's current fleet of pressurised heavy water reactors (PHWRs) and its planned thorium-based reactors, which will seek to harness India's abundant thorium reserves for centuries of clean energy.

The Prototype Fast Breeder Reactor

Fast breeder reactors globally have faced persistent delays and cost escalations, partly due to the engineering complexity of using liquid sodium coolant, which is highly reactive and comes with corrosion, leak and fire risks, necessitating stringent safety systems and complicating plant operations. Only Russia currently operates large fast breeder reactors.

"India has entered the 2nd stage of our three-stage nuclear power programme with the achievement of criticality of PFBR," the former DAE secretary Anil Kakodkar wrote on Monday night in a post on X.

The DAE has described the PFBR criticality as a "historic step" towards long-term energy security and advancing homegrown nuclear technology capabilities.

Kakodkar has previously called for steps to accelerate the transition to the third stage, which he said was critical for long-term energy security and reducing reliance on fossil fuels.

India currently operates the sixth-largest nuclear reactor fleet in the world with 24 operational reactors and an installed nuclear power capacity of nearly 8.8GW. Seventeen planned or under-construction reactors will add 22.38GW by 2032. The government has set a target of 100GW by 2047.

Nuclear energy currently makes up 3.1 per cent of the country's total electricity generation.

A Parliamentary panel reviewing the atomic energy department's activities last month had expressed concern that the current pace of capacity addition falls "significantly short" of what would be required to realise the planned 100GW target.

The panel had recommended that the Centre should establish a "ring-fenced funding mechanism" for nuclear capacity addition, insulated from year-to-year budgetary variability to provide long-term financial certainty to ongoing and planned nuclear power reactors.

The panel had also asked the DAE to prepare a roadmap for the transition from stage two to stage three, including projected timelines for a fleet-mode deployment of fast breeder reactors.

The existing PHWRs use natural uranium to produce plutonium, which is then used in the second stage along with thorium to generate fissile uranium-233. In the third stage, thorium is used to continue the production of uranium-233, enabling a self-sustaining fuel cycle.