Roadmap for Self-Reliant Nuclear Energy Ecosystem

Prelims : *Current events of National and International Importance | Science and Tech*

Why is in news?

Minister of State for Personnel, Public Grievances & Pensions and Prime Minister's Office Dr. Jitendra Singh Presents ***Government's Roadmap for a Self-Reliant and Globally Competitive Nuclear Energy Ecosystem*** *in Lok Sabha.*

Clear Roadmap

- India accelerates Indigenous Nuclear Energy Push with Focus on ***SMRs (Small Modular Reactors),*** Thorium and Private Sector.
- It highlights 100 GWe Nuclear Energy Target by 2047, Indigenous SMRs and Three-Stage Nuclear Programme.
- India's long-term nuclear energy strategy continues to be guided by the country's three-stage nuclear power programme.
- The Government has adopted a two-pronged approach to accelerate nuclear capacity addition.

This includes

I. Deployment of large indigenous reactors such as 700 MWe Pressurized Heavy Water Reactors (PHWRs) and advanced reactor designs at greenfield sites
II. Deployment of Small Modular Reactors (SMRs) at brownfield locations, including retiring fossil-fuel-based power plants, captive plants for energy-intensive industries and off-grid applications in remote areas

Key Objectives

- A key objective under the Nuclear Energy Mission is to develop and operationalize at least ***five indigenous SMRs by 2033***.
- The Bhabha Atomic Research Centre (BARC), a constituent unit of the

Department of Atomic Energy (DAE), is undertaking the design and development of indigenous SMR technologies, including the 220 MWe Bharat Small Modular Reactor (BSMR-200) and 55 MWe SMR-55 for power generation.

- BARC is also developing a High Temperature Gas Cooled Reactor (HTGCR) of up to 5 MWth capacity, which can be coupled with a suitable thermochemical cycle for hydrogen production.
- Indira Gandhi Centre for Atomic Research (IGCAR) is in advancing the second stage of India's nuclear power programme.
- IGCAR is pursuing multidisciplinary scientific research and advanced engineering development for Sodium Cooled Fast Breeder Reactors and associated closed fuel-cycle facilities, technologies that remain a cornerstone of India's long-term nuclear strategy.

Recent steps

- Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India ***(SHANTI) Act, 2025*** has been enacted to enable wider participation of both public and private entities in the nuclear sector.
- The reforms under the ***SHANTI Act*** envisage greater participation of private entities in nuclear manufacturing, engineering services, research and development and supply chains, while maintaining stringent standards of nuclear safety, security and safeguards.
- The Act also provides ***statutory status to the Atomic Energy Regulatory Board***, thereby reinforcing the framework for robust regulatory oversight.

INDIA'S THREE-STAGE NUCLEAR POWER PROGRAMME

Envisaged by Homi J. Bhabha in 1950s to achieve energy security through optimum utilisation of India's nuclear resources.

THE STRATEGY

India has limited uranium but abundant thorium.
The programme aims to use uranium in the beginning and thorium in the long term to ensure sustainable energy.

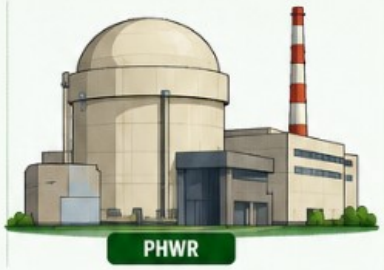
Natural Uranium (Limited) → Plutonium (From PHWRs) → Thorium (Abundant)

STAGE 1 — USE OF NATURAL URANIUM

Objective:
To produce electricity and generate plutonium.

Fuel
Natural Uranium (as UO_2)

Reactors
Pressurised Heavy Water Reactors (PHWRs)



Process
- Natural uranium is used as fuel in PHWRs.
- Generates electricity.
- Produces plutonium-239 as a by-product.

Outcome
Electricity + Plutonium-239 (for use in Stage 2)

Example
Tarapur, Rajasthan, Kakrapar, Narora, Kaiga, Kudankulam (Units 1 & 2)

STAGE 2 — USE OF PLUTONIUM

Objective:
To utilise plutonium produced in Stage 1 to generate more electricity.

Fuel
Plutonium (from Stage 1) + Natural Uranium

Reactors
Fast Breeder Reactors (FBRs)

Process
- Plutonium is used with natural uranium in FBRs.
- Produces more electricity.
- Breeds more plutonium-239 than it consumes.
- Also produces some Uranium-233 from thorium (in the blanket).

Outcome
Electricity + More Plutonium + Uranium-233 (for Stage 3)

Example
Prototype Fast Breeder Reactor (PFBR) at Kalpakkam (500 MWe) – under operation.

STAGE 3 — USE OF THORIUM

Objective:
To use thorium (India's vast resource) to generate sustainable energy.

Fuel
Thorium-232 → Uranium-233

Reactors
Advanced Heavy Water Reactors (AHWRs) / Thorium-based Reactors

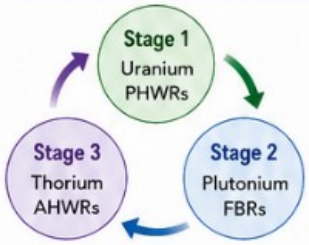
Process
- Thorium is converted to Uranium-233 in the reactor.
- Uranium-233 is used as fuel in AHWRs.
- Produces electricity with minimal long-lived nuclear waste.

Outcome
Large-scale electricity generation using India's abundant thorium resources.

Example
AHWR (300 MWe) – under development by BARC.

KEY FEATURES

- Ensures energy security for centuries.
- Minimises nuclear waste and improves sustainability.
- Indigenous technology and self-reliance.
- Supports India's goal of clean and reliable energy.



WHY INDIA FOLLOWED THIS PATH?

- Limited uranium resources
- Large thorium reserves (~25% of the world's total)
- Long-term sustainable and self-reliant energy future

In short: Stage 1 uses natural uranium, Stage 2 multiplies plutonium, and Stage 3 uses thorium to provide a near-limitless source of clean nuclear energy.

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PIB | Roadmap for a Self-Reliant and Globally Competitive Nuclear Energy Ecosystem