HALEU Fuel Cycle as an Alternative to FBRs

Source: IE

Why in News?

India's **3-stage nuclear power programme is** facing delays in deploying **Fast Breeder Reactors (FBRs).** Amid these challenges, the **former Bhabha Atomic Research Centre (BARC) chief** has suggested using **HALEU and thorium** as fuel to effectively utilize existing **PHWRs.**

How Can Thorium-HALEU Fuel Be Integrated into India's Nuclear Programme?

- **Using PHWRs with HALEU:** India can enhance its nuclear energy programme by using a **mix of High Assay Low Enriched Uranium (HALEU)** and **thorium** in existing **700 MWe Pressurised Heavy Water Reactors (PHWRs).**
    - **HALEU** is uranium enriched between **5% and 20% U-235.** This approach enables India to **start utilizing thorium sooner,** making its **nuclear power generation more sustainable.**
- **Recycling Spent Fuel:** The **spent fuel from PHWRs using HALEU-thorium** can be **reprocessed to extract valuable fissile material** (substance whose nucleus can undergo fission when struck by a neutron).
    - This reprocessed material can then be **utilized in advanced reactors** such as **Molten Salt Reactors (MSRs)**, which form part of India's **3rd stage of its nuclear programme**.
    - It ensures **optimal use of nuclear fuel,** contributing to the long-term sustainability of India's nuclear energy sector by **minimizing waste and maximizing fuel efficiency.**

What is India's 3-Stage Nuclear Power Programme?

- **About**: India's 3-Stage Nuclear Power Programme, formulated by **Dr. Homi Bhabha,** aims to **achieve long-term energy security** by **efficiently utilising** India's **limited uranium and abundant thorium reserves**.
    - It is a **phased plan** to **develop nuclear energy** in a **sustainable and self-reliant manner.**
- **3 Stages:**

Stage	Aim	Fuel/Coolant/ Moderator	Nuclear Reactor	Current Status
	It aims to generate electricity while producing **plutonium-239 (Pu-239)** as a byproduct. Plutonium is key for the	Uranium (U-238) Moderator: **Heavy water (deuterium oxide)**	Pressurized Heavy Water Reactors (PHWRs)	India has already constructed **18 PHWRs,** as the **foundation of India's nuclear power infrastructure.**

	next stages of the programme.			
Stage-2	It focuses on **Fast Breeder Reactors (FBRs)**, which utilize **Pu-239** from the first stage to generate more fissile material than they consume. These reactors convert fertile uranium-238 into Pu-239, enhancing the nuclear fuel cycle efficiency.	Mixed **Oxide of Plutonium-239 a**nd **Uranium-238**	Fast Breeder Reactors (FBRs)	The Prototype FBR at **Kalpakkam, Tamil Nadu**, is a key development in this stage.
Stage-3	It focuses on **Thorium Reactors,** which use Thorium-232 to produce uranium-233, a fissile material.	**Thori um-232** (converted into Uranium-233)	Thorium-Based Reactors (Thorium Cycle)	Research into thorium-based reactors is ongoing, with the **Advanced Heavy Water Reactor (AHWR)** & **Molten Salt Reactors** being developed as part of this stage.

India's Nuclear Weapon Programme

- **Smiling Buddha (1974):** India's **first successful nuclear test** conducted at **Pokhran,** Rajasthan, making it the **6th country** (after the US, Soviet Union, United Kingdom, France, and China) to possess nuclear capability.
- **Operation Shakti (1998):** A series of **5 nuclear tests (Pokhran-II),** including a **thermonuclear device**, which demonstrated India's advanced nuclear weapons capability.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. In India, why are some nuclear reactors kept under "IAEA safeguards" while others are not? (2020)

(a) Some use uranium and others use thorium

(b) Some use imported uranium and others use domestic supplies

(c) Some are operated by foreign enterprises and others are operated by domestic enterprises

(d) Some are State-owned and others are privately owned

Ans: (b)