



Small Modular Reactors for Decarbonization

For Prelims: [Low-Carbon Electricity Resources](#), [Decarbonization](#), [International Energy Agency \(IEA\)](#), [Rare Earth Elements](#), [International Atomic Energy Agency \(IAEA\)](#), [Atomic Energy Act, 1962](#).

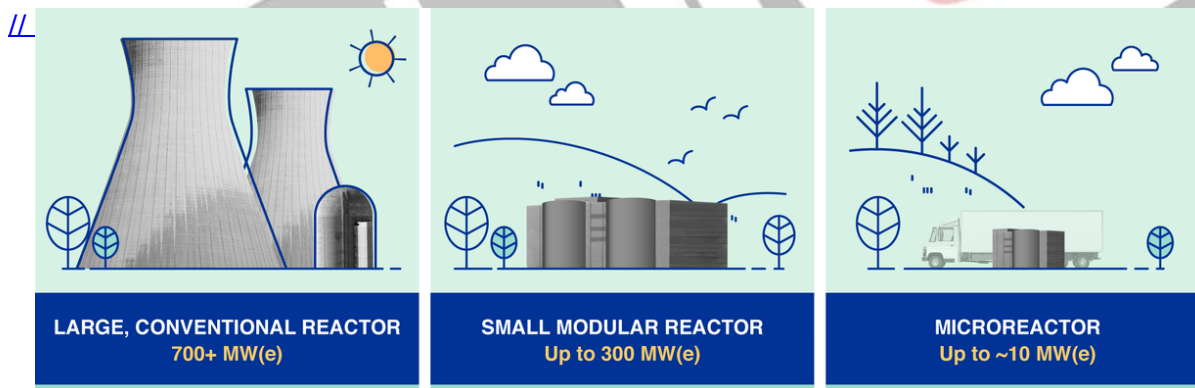
For Mains: Small Modular Reactors for Decarbonization.

[Source: TH](#)

Why in News?

The rise in coal consumption despite increased solar and wind power underlines the need for Low-Carbon Electricity Resources such as **Small Modular Reactors (SMRs)** to ensure Deep [Decarbonization](#).

- Conventional [NPPs \(Nuclear Power Plants\)](#) have generally suffered from **time and cost overruns**. As an alternative, several countries are developing (SMRs) – nuclear reactors with a maximum capacity of **300 MW** - to complement conventional NPPs.



What is Decarbonization?

- About:**
 - Decarbonization refers to the process of reducing the **Carbon Dioxide (CO₂) Emissions** produced by human activities, particularly those related to the burning of fossil fuels such as [Coal](#), [Oil](#), and [Natural gas](#).
- Need:**
 - The global pursuit of decarbonization aligns with the [UN Sustainable Development Goal 7](#), which emphasizes **affordable and sustainable energy access**.
 - However, the world's heavy reliance on fossil fuels, **constituting 82% of energy supply**, necessitates the urgent decarbonization of the power sector.
 - The rise in coal consumption in Europe despite increased solar and [Wind Power](#) underlines the need for reliable low-carbon electricity resources to ensure deep

decarbonization, grid stability, and energy security.

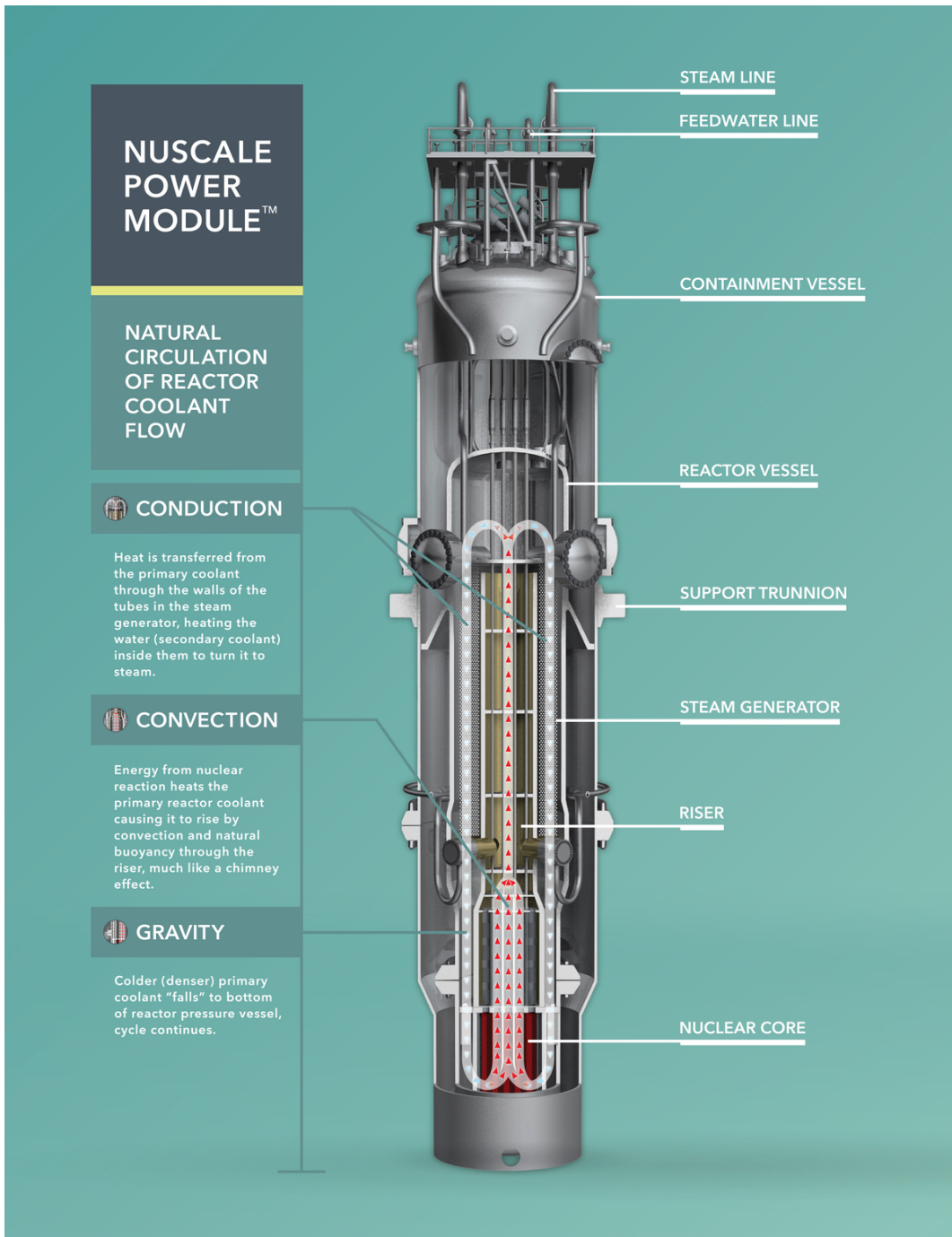
▪ **Challenges of Decarbonization:**

- **Clean Energy Transition Challenges:** The shift from **coal to clean energy is a complex challenge** globally. Several nations concur that relying solely on solar and wind energy would not suffice **reliable and affordable energy** access for all.
 - In decarbonized power systems dominated by renewables, introducing at least one **stable power source enhances grid reliability and reduces expenses**, contributing to a balanced energy mix.
- **Critical Minerals Demand and Complexities:** The [International Energy Agency \(IEA\)](#) predicts a potential 3.5x surge in demand for **critical minerals like lithium, nickel, cobalt, and Rare Earth Elements** by 2030, essential for clean energy technologies.
 - However, this demand **escalation raises multiple global issues**, including the large capital investments to develop new mines and processing facilities.
- **Challenges in the Mineral Supply Chain:** Rapid development in countries like **China, Indonesia, Africa, and South America**, coupled with concentration of mineral extraction and processing capacities, presents **environmental, social, geopolitical, and supply risks**.
 - Addressing these challenges becomes critical for sustainable clean energy advancement.

What are Small Modular Reactors (SRMs)?

▪ **About:**

- SMRs are **advanced nuclear reactors** that have a power capacity of up to **300 MW(e) per unit**, which is about one-third of the generating capacity of traditional **nuclear power reactors**.
- SMRs, which can produce a large amount of low-carbon electricity, are,
 - **Small:** Physically a fraction of the size of a conventional nuclear power reactor.
 - **Modular:** Making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.
 - **Reactors:** Harnessing nuclear fission to generate heat to produce energy.
- Their designs incorporate **enhanced safety features**, reducing the risk of uncontrolled radioactive material release.
 - SMRs are designed to operate for **40-60 years with capacity factors exceeding 90%**.



▪ **Advantages:**

◦ **Reliable Low-carbon Electricity Source:**

- As the demand for electricity is projected to surge by **80-150% by 2050**, SMRs could provide a **reliable 24/7 low-carbon electricity** source that complements intermittent renewables.
- This is crucial for achieving **grid reliability and reducing costs in decarbonized** electricity systems.

◦ **Minimized Land Acquisition Challenges:**

- SMRs generate less spent nuclear fuel and can be safely operated in existing brownfield sites, minimizing land acquisition challenges.
- SMRs are also simpler to design and manufacture, with potential for cost reduction through serial manufacturing.

◦ **Alternatives to Critical Minerals:**

- The transition to clean energy requires **Critical Minerals** for technologies like **lithium-ion batteries**, leading to concerns about geopolitical risks and environmental impacts.
- SMRs offer an alternative, as they require **low-enriched uranium**, which is more

widely distributed than critical minerals.

- **Integration with India's Energy Strategy:**

- For India, which aims to achieve net-zero emissions by 2070, SMRs can play a pivotal role. As coal-based thermal power plants and variable renewable energy sources **contribute significantly to the energy mix**, SMRs can enhance energy security and grid stability.
 - India's **Central Electricity Authority** envisions SMRs as a crucial element in meeting electricity demands, while private sector investments, including public-private partnerships, are vital for expansion.

How can Low-Carbon Electricity Resources be Promoted for Decarbonization?

- An efficient regulatory regime comparable to that in the civil aviation sector – which has more stringent safety requirements – is important if **SMRs are to play a meaningful role in decarbonising** the power sector.
- This can be achieved if all countries that accept nuclear energy **direct their respective regulators to cooperate amongst themselves** and with the [International Atomic Energy Agency \(IAEA\)](#) to harmonize their regulatory requirements and expedite statutory approvals for SMRs based on standard, universal designs.
- To facilitate SMR deployment, India needs to amend the [Atomic Energy Act, 1962](#) to allow private sector involvement.
- While maintaining government control over nuclear fuel and waste, an independent regulatory board should oversee the entire nuclear power cycle.
- The **India-US '123 agreement' provides opportunities** for India to reprocess spent fuel from SMRs under IAEA safeguards, contributing to resource sustainability.
 - It also permits India to set up a facility to reprocess spent fuel from SMRs under safeguards of the IAEA.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. The function of heavy water in a nuclear reactor is to (2011)

- (a) Slow down the speed of neutrons
- (b) Increase the speed of neutrons
- (c) Cool down the reactor
- (d) Stop the nuclear reaction

Ans: (a)

Mains

Q. With growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy. (2018)