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.

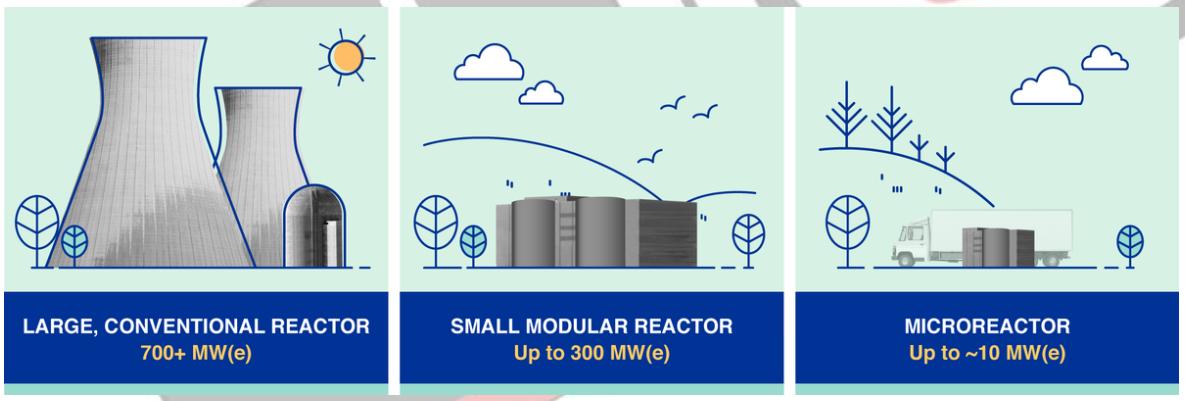
For Mains: Small Modular Reactors for Decarbonization.

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.**



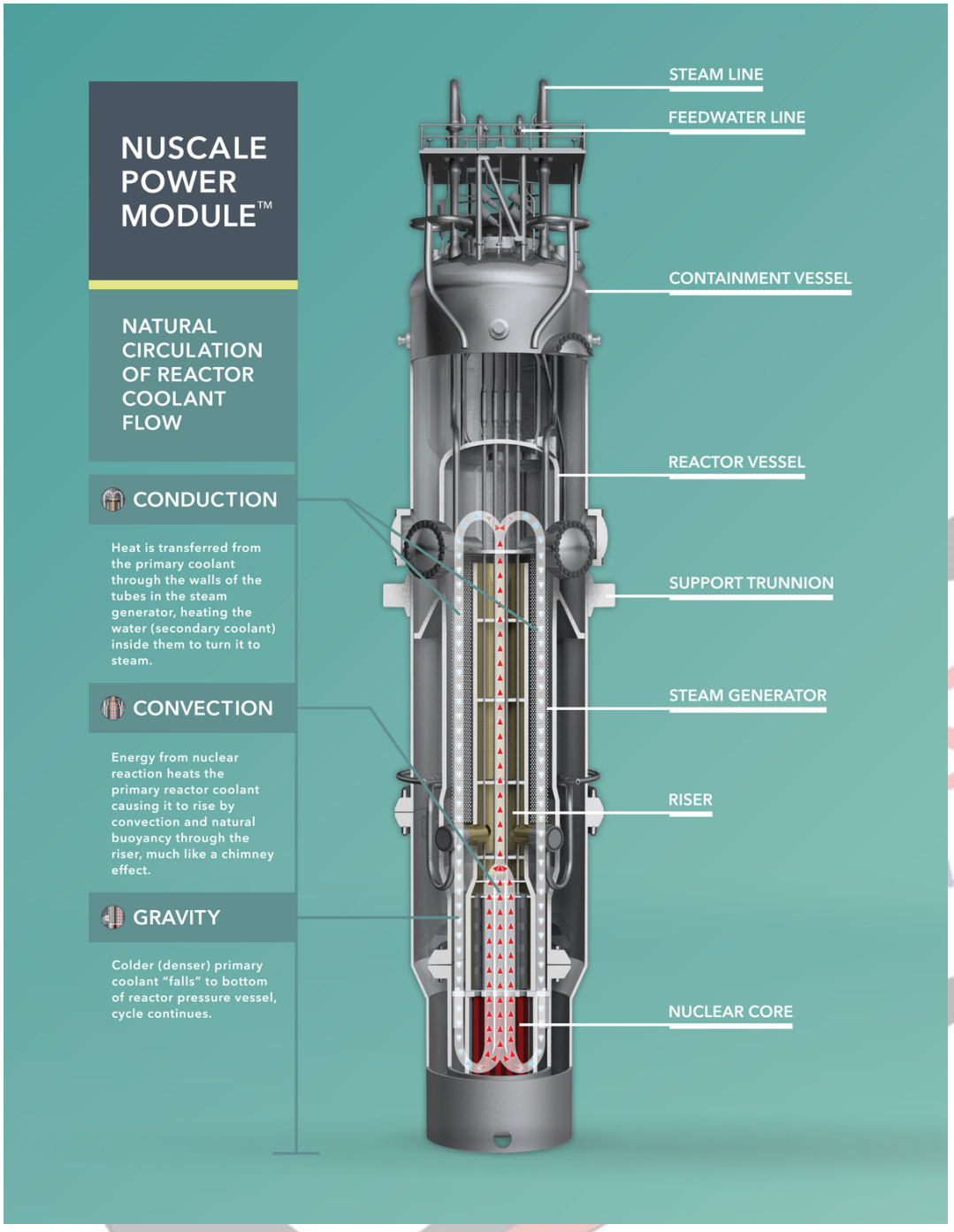
What is Decarbonization?

- **About:**
  - Decarbonization refers to the process of reducing the **Carbon Dioxide (CO_2) 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)**