Kakrapar Atomic Power Project

Why in news?

The third unit of Kakrapar Atomic Power Project (KAPP-3) in Gujarat achieved its 'first criticality'.

What is KAPP-3?

- KAPP-3 is the first 700 MWe (Mega Watt electric) unit of India.
- It is the biggest indigenously developed variant of the Pressurised Heavy Water Reactor (PHWR).

What does achieving criticality mean?

- **First criticality** is a term that signifies the initiation of a controlled but sustained nuclear fission reaction.
- In the reactors of an atomic power plant, a controlled nuclear fission reaction takes place.
- **Fission** is a process in which the nucleus of an atom splits into two or more smaller nuclei, and usually some by-product particles.
- When the nucleus splits, the kinetic energy of the fission fragments is transferred to other atoms in the fuel as heat.
- This heat is used to produce steam to drive the turbines to create electricity.
- For every fission event, if at least one of the emitted neutrons on average causes another fission, a self-sustaining chain reaction will take place.
- A nuclear reactor achieves criticality when each fission event releases a sufficient number of neutrons to sustain an ongoing series of reactions.

Why is this achievement significant?

- The achievement by KAPP-3 is a landmark event in India's domestic civilian nuclear programme.
- The PHWRs are the mainstay of India's nuclear reactor fleet.
- [PHWRs use natural uranium as fuel and heavy water as moderator.]
- Until now, the biggest reactor size of indigenous design was the 540 MWe PHWR.

- The operationalisation of this new 700 MWe reactor marks a significant scale-up in technology, both in terms of,
    1. Optimisation of its PHWR design (the new 700MWe unit addresses the issue of excess thermal margins),
    2. Improvement in the economies of scale, without significant changes to the design of the 540 MWe reactor.
- [Thermal margin refers to the extent to which the operating temperature of the reactor is below its maximum operating temperature.]
- Four units of the 700 MWe reactor are currently being built at Kakrapar (KAPP-3 and 4) and Rawatbhata (RAPS-7 and 8).

What is the significance of 700MWe reactors?

- These reactors will be the backbone of a new fleet of 12 reactors to which the government gave approval and financial sanction in 2017.
- India is working to ramp up its existing nuclear power capacity of 6,780 MWe to 22,480 MWe by 2031.
- The 700MWe capacity would constitute the biggest component of this expansion plan.
- Currently, nuclear power capacity constitutes less than 2% of the total installed capacity of 3,68,690 MW (end-January 2020).
- The civilian nuclear sector is gearing up for building a 900 MWe Pressurised Water Reactor (PWR) of indigenous design.
- For this, the experience of executing the larger 700MWe reactor design will come in handy.

What are the upgraded safety features in the 700MWe unit?

- PHWR design uses **thin walled pressure tubes**, instead of the large pressure vessels used in pressure vessel type reactors.
- This results in the distribution of pressure boundaries to several small-diameter pressure tubes.
- This lowers the severity of the consequence of an accidental rupture of the pressure boundary.
- The 700 MWe PHWR design has enhanced safety through a dedicated '**Passive Decay Heat Removal System**'.
- This system can remove decay heat (released from radioactive decay) from the reactor core without requiring any operator actions.
- The 700 MWe PHWR unit is equipped with a **steel-lined containment** to reduce any leakages.
- It also has a **containment spray system** to reduce the containment pressure in case of a loss of coolant accident.

How did India’s PHWR technology evolve?

- PHWR technology started in India in the late 1960s.
- It was started with the construction of the first 220 MWe reactor, Rajasthan Atomic Power Station, RAPS-1.
- RAPS-1 was built under the joint Indo-Canadian nuclear co-operation,
    1. Canada supplied all the main equipment for this first unit.
    2. India was responsible for construction, installation, and commissioning.
- The first two units of PHWR using indigenously developed 220 MWe design were set up at the Narora Atomic Power Station.
- To realise economies of scale, the design of 540 MWe PHWR was subsequently developed, and two such units were built at Tarapur.
- Further optimisations were carried out when the upgrade to 700 MWe capacity was undertaken, with KAPP-3 the first unit of this kind.

Source: The Indian Express