KALPAKKAM NUCLEAR POWER PLANT - GS III MAINS

Q. How does nuclear power make India energy independent and enumerate the challenges associated with India's Nuclear Programme. (15 marks, 250 words)

News: *PM Modi witnesses commencement of core loading at India's first indigenous Fast Breeder Reactor at Kalpakkam*

What's in the news?

- The vital second stage of India's three-stage nuclear programme got a boost with the commencement of **'core loading' at the country's first indigenous Fast Breeder Reactor (FBR) at Kalpakkam, Tamil Nadu**, earlier this month.

Core Loading:

- In a nuclear reactor, core loading is the **process of loading nuclear fuel assemblies into the reactor core.**
- The fuel assemblies comprise fuel rods that contain fissile material, such as enriched uranium or plutonium, which undergoes nuclear fission to produce heat.
- A **fast breeder reactor** is a type of nuclear reactor that is designed to **produce more fissile material (such as Plutonium-239)** than it consumes during operation.
- It achieves this by using fast neutrons to convert non-fissile isotopes (such as Uranium-238) into fissile isotopes (such as Plutonium-239).
- This process is known as "**breeding**" because it creates more fissile material than is initially loaded into the reactor.

Capacity of PFBR in Tamil Nadu:

- India's prototype fast breeder reactor (PFBR) in Tamil Nadu has a capacity of 500 Megawatt electric (MWe).
- It was designed by the Indira Gandhi Centre for Atomic Research and constructed by **BHAVINI**.
    - Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) was established in 2003 to build and operate the PFBR.

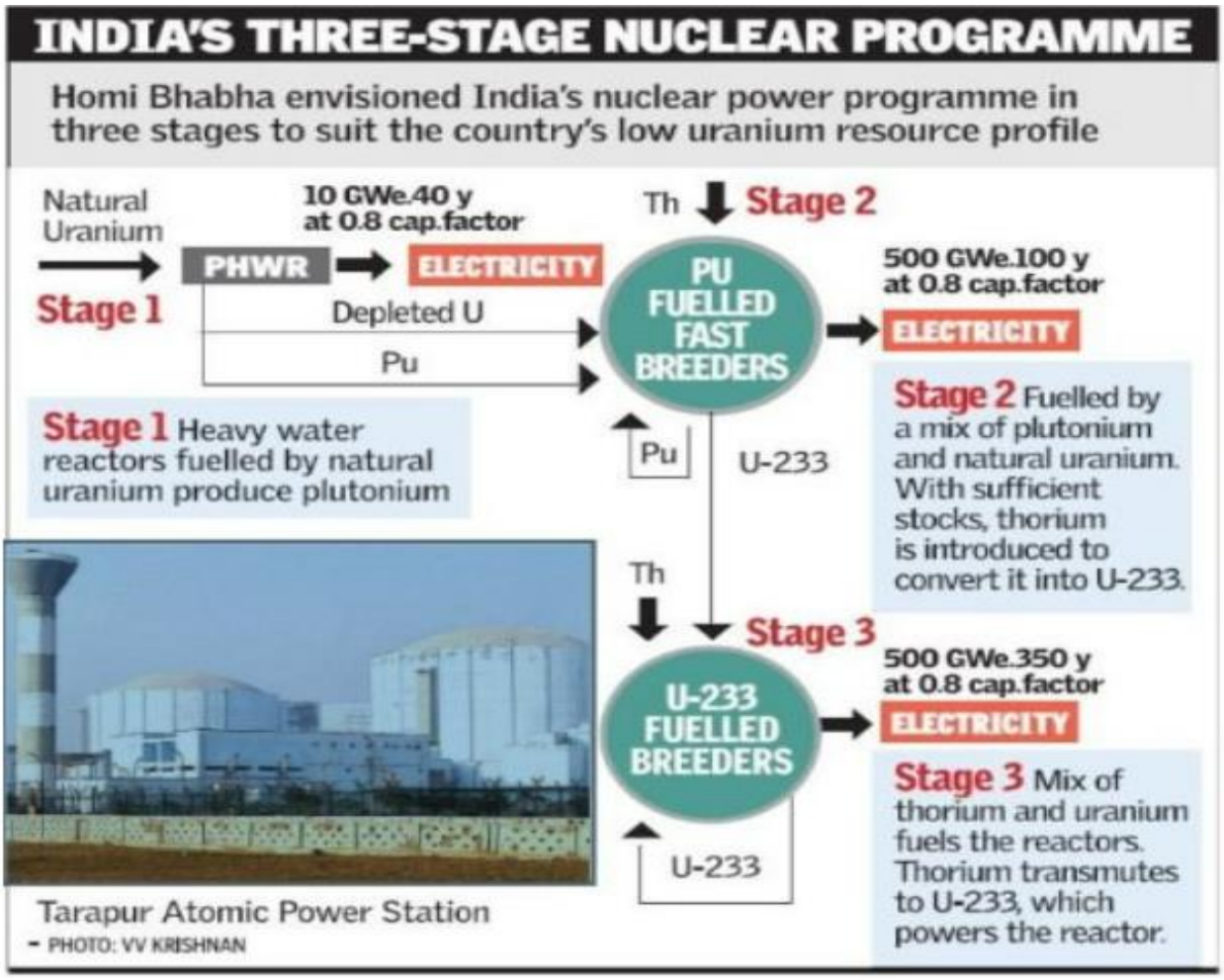
Significance:

- PFBR is considered a precursor to future fast breeder reactors (FBRs).
- After the core loading is completed, the Kalpakkam PFBR reactor will undergo the first approach to criticality, leading to power generation.
- Once it becomes operational, India will be only the second country after Russia to have a commercial operating fast breeder reactor.

- The latest development symbolises India's entry into the crucial second stage of the country's three-stage nuclear programme.

Go back to basics:

India's Three Staged Nuclear Programme:



Significance of India's Nuclear Program:

1. Energy Sovereignty:

- Fossil-based energy sources contributed about 82% of the primary energy supplied in 2021.
- India imports a significant part of its fossil fuels (coal and gas) for energy generation.
- Bulk fuel imports raise economic and strategic vulnerabilities for a developing country like India.
- Nuclear energy can help India reduce its dependence on imported fuel.

2. Decarbonisation of Power Sector:

- Thermal power plants have high carbon footprint as they contribute heavily to global warming, climate change and air pollution.
- Nuclear power plants will help in decarbonising the power sector.

3. Limitations Attached with Other Renewable Energy Sources:

- Solar energy is land intensive, wind energy requires energy storage systems.
- They also require imported technologies and materials such as photovoltaic cells, batteries, and storage equipment.
- On the other hand, indigenous nuclear reactors have reduced dependency in critical imports.

4. Cheaper to Operate:

- Nuclear power plants are cheaper to operate than coal or gas plants, despite the cost of managing radioactive fuel and disposal.
- According to estimates, nuclear plants cost only 33-50% of a coal plant and 20-25% of a gas combined-cycle plant.

5. Reliable and Continuous Power:

- Nuclear energy provide reliable and continuous base load power, unlike solar and wind energy, which are intermittent and dependent on weather conditions.

6. Resource Base:

- India has vast thorium reserves which could be exploited using a thermal breeder reactor.
- A significant amount of thorium reserves is found in the monazite sands of coastal regions of South India.

Challenges in India's Nuclear Program:

1. Capital Intensive:

- Nuclear power plants are capital intensive. There have been cost over runs in recently built nuclear power plants.

2. Insufficient Installed Capacity:

- The current installed capacity is only 6.78 GW, against the vision of 650GW of installed capacity by 2050 set by the Atomic Energy Commission.

3. Nuclear Safety:

- Local communities in India have been resisting nuclear reactors due to fears of nuclear disasters like Chernobyl, 1986 or Fukushima, 2011.
- For example, locals protesting against the Mithi virdi nuclear project in Gujarat.

4. Nuclear Liability:

- India’s Civil Liability for Nuclear Damage Act 2010, has been a contentious issue for foreign suppliers.
- Foreign suppliers have been reluctant to invest in India’s Nuclear Energy Programs due to fears of being held accountable for accidents beyond their control.

5. Hurdles Created by NSG and NPT:

- India's non-ratification of NPT and lack of NSG membership, has created diplomatic hurdles in accessing more nuclear fuel and better nuclear technologies.

6. Use of Outdated Technology:

- Currently operational Indian nuclear reactors have become outdated and suffer from multiple operational probles.
- For example, 6 VVER (water-water energy reactor) design reactors encountering operational problems at Kudankulam.

WAY FORWARD:

1. Small Modular Reactors (SMRs):

- Indigenous Small Modular Reactors (SMRs) must be built at coal plant sites which would be retiring in the coming decades.
- SMRs offer the advantages of being safe, economical, compact and adaptable. Partnerships with NTPC and other thermal plant owners must be explored.

2. Expansion of Indigenous PHWR Reactors:

- The Indigenous 700 MWe PHWR, must be expanded in fleet mode to add to the installed nuclear power capacity in India.

3. Push to the Stage-3 of Nuclear Power Program:

- The second and third stages of nuclear-power programme must be propelled to utilise the existing thorium energy potential in the country.

4. Development of Nuclear Fusion Technology:

- The development of nuclear fusion technology must be explored, which is safer than nuclear fission.
- The vast reserves, in the form of ocean water, will be added advantage for India.

5. Augmentation of Safety of Nuclear Facilities:

- There must be constant updation of safety skills of nuclear operators.
- Further, masses must be comprehensively sensitised about the functioning of nuclear power plants using highly intellectual individuals having mass appeal.
- For example, Dr APJ Abdul Kalam sensitizing the masses before the establishment of the Kudankulam nuclear power plant.

6. Ensuring Regulatory Autonomy:

- The AERB, India's nuclear regulatory body, must be provided functional autonomy by removing its reporting from the Department of Atomic Energy (DAE).