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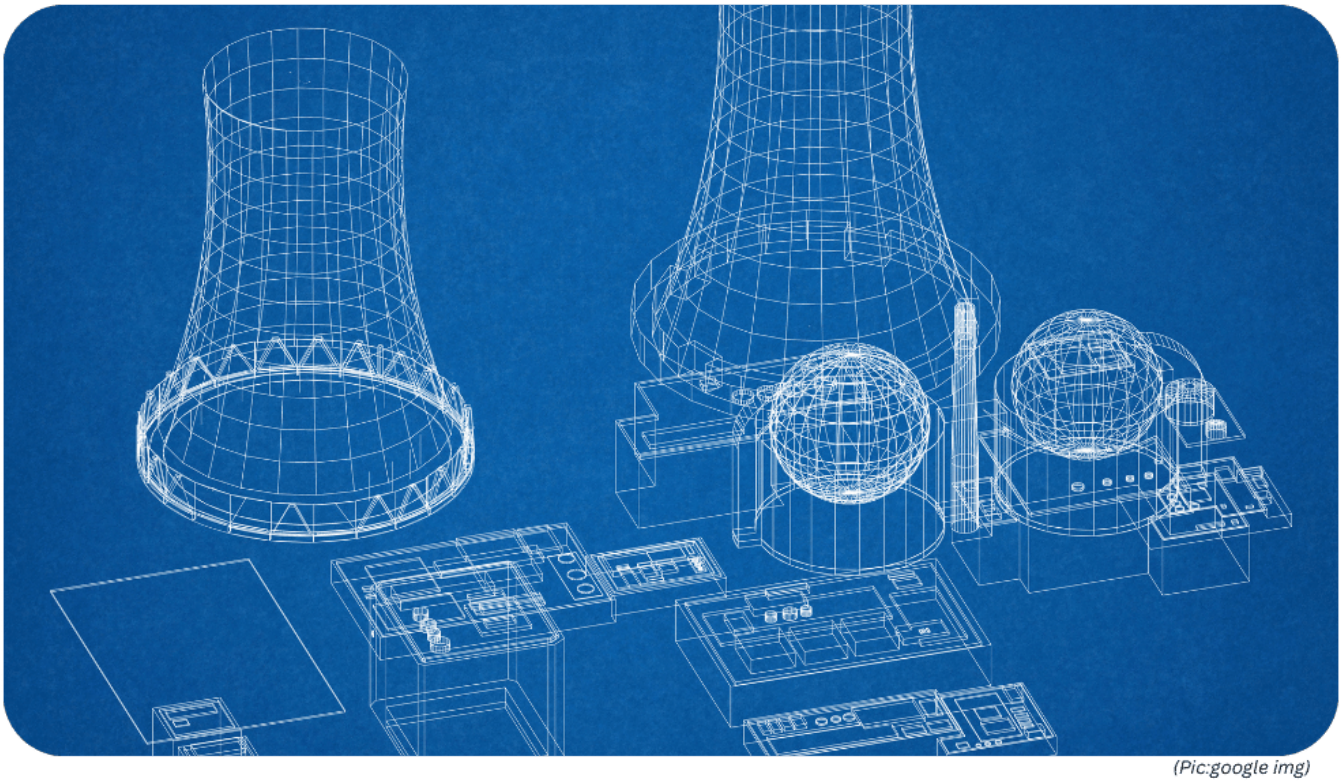
Topics Covered

Why is the news?

- Prime Minister Narendra Modi on Monday visited a nuclear power plant , where a key procedure regarding power generation commenced.
- The commencement of ‘core loading’ of the country’s indigenous Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, located about 60 km from Chennai happened in the presence of the PM.

What is India’s first Fast Breeder Reactor and how it works?



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India’s First Fast Breeder Reactor: Prototype Fast Breeder Reactor (PFBR)

1. **Name:** Prototype Fast Breeder Reactor (PFBR)
2. **Location:** Kalpakkam, Tamil Nadu, India
3. **Working Principle:**

- The PFBR is a type of nuclear reactor known as a fast breeder reactor. Unlike conventional reactors, it produces more fissile material (fuel) than it consumes. Here’s a simplified explanation of its working:

- **Fuel:** The PFBR uses a mixture of plutonium and uranium oxide (MOX fuel) as its primary fuel.

- **Fission:** When neutrons collide with the plutonium nuclei, they undergo fission, releasing a large amount of energy and additional neutrons.

- **Breeding:** A “blanket” of fertile material (Uranium-238) surrounds the fuel core. These neutrons from fission can interact with the Uranium-238, converting it into fissile Plutonium-239 through a process called transmutation.

- **More Fuel:** This newly created Plutonium-239 can then be used as fuel in other reactors, effectively “breeding”

more fuel from the initial fuel used.

Benefits:

- Fuel Efficiency: FBRs use fuel more efficiently than traditional reactors, extracting more energy.
- Waste Reduction: They may reuse spent reactor fuel, lowering radioactive waste.
- Strategic Independence: FBRs can reduce fissile fuel imports in countries with ample fertile resources like thorium.

Challenges:

- Technical Complexity: FBRs are harder to develop and run than conventional reactors.
- Safety: Plutonium and fast neutrons pose safety risks that must be handled through strict protocols and public education.

- **Economic Viability:** FBR technology is promising, but it needs further research and refinement to be competitive.

- *Fast Breeder Reactors can reduce waste and use fuel effectively, delivering a more sustainable and safe nuclear energy future. For successful deployment, technological, safety, and economic difficulties must be overcome.*

What is Fissile fuel?

- Fissile fuel is a type of nuclear fuel that produces energy through fission. Fissile materials are atoms that can split by neutrons in a self-sustaining chain reaction. This reaction releases large amounts of energy, which is used to generate electricity in nuclear reactors.

What is Prototype in Prototype Fast Breeder Reactor ?

In the context of the Prototype Fast Breeder Reactor (PFBR), "Prototype" refers to the initial, experimental version of the reactor design. Here's why:

- Fast breeder technology is used to test and develop India's first PFBR. It's a prototype to test this technology's practicality, performance, and safety before general deployment.
- Collection and analysis: Engineers and scientists use PFBR operational data and experience to improve the design, find improvements, and overcome unexpected problems.
- Learning and development: Building and operating the PFBR promotes fast breeder technology learning and development in India, laying the way for future growth and commercialization.

- Therefore, the “Prototype” in PFBR represents its pioneering and experimental role in fast breeder reactor technology development in India.

India’s First Fast Breeder Reactor in Chennai(Kalpakkam) : Why is it Important?

- The core loading of India’s first indigenous Fast Breeder Reactor (PFBR) is a major step towards energy security and self-reliance. This advanced reactor technology can solve several problems and help India achieve energy sustainability.

Better Fuel Economy and Waste Reduction:

- FBRs “breed” fissile fuel from non-fissile uranium-238 into plutonium-239, unlike conventional nuclear reactors. This technique boosts fuel efficiency and uranium energy extraction. FBRs may also reuse spent fuel from Pressurised Heavy Water Reactors (PHWRs), India’s largest nuclear power plant, decreasing radioactive waste. This creates a greener nuclear fuel cycle.

Strategic Independence and Import Reduction:

- Indian thorium reserves are abundant and can be used in FBRs to manufacture fissile uranium-233.
- Thorium reserves are three times more abundant than uranium. If FBR technology works, India can cut its uranium imports for nuclear fuel, increasing its energy sector strategic independence. Self-reliance is essential in a world of fluctuating energy markets and geopolitical uncertainty.

Clean, Sustainable Energy:

- Baseload electricity from nuclear power, especially FBRs, is clean and reliable. FBRs help India meet its renewable energy and climate change goals by not emitting greenhouse emissions.

Job creation and technological advancement:

- The PFBR shows India’s nuclear technology advancement. This achievement allows for enhanced reactor designs and fuel cycles, strengthening India’s nuclear energy leadership. FBR construction and operation will enhance the domestic nuclear industry by creating skilled jobs

in numerous industries.

Challenges and Future:

- PFBR is a major advance, but problems remain. Transparent communication and strong safety measures must improve nuclear safety perception.
- FBR technology needs further study and development to be economically viable.

India’s first indigenous FBR shows its dedication to energy security, sustainability, and technology. India can unleash FBR technology’s potential for a cleaner, more secure energy future by overcoming its hurdles.

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Are you Ready!

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General Studies

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- Click on - Check Result
- Scroll down - Check out Solutions too.

Thank you.

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Category: **General Studies**

The successful core loading of India's first indigenous FBR signifies:

○ The immediate solution to India's energy crisis.

○ A significant milestone towards self-reliance in nuclear

fuel production.

○ The complete elimination of risks associated with nuclear energy.

○ The phasing out of all conventional nuclear power plants.

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Category: **General Studies**

A potential benefit of FBRs for India's energy security is:

○ Reducing the need for thermal power plants.

○ Increasing dependence on imported fossil fuels.

○ Enhancing fuel efficiency and reducing reliance on foreign fuel.

○ Eliminating the generation of any radioactive waste.

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Category: **General Studies**

Which of the following statements about the significance of the PFBR is NOT true?

○ It can potentially reduce India's dependence on imported uranium for nuclear energy production.

○ It offers a potential solution for the management of plutonium, a by-product of conventional nuclear reactors.

○ It utilizes a simpler and less complex technology compared to conventional nuclear reactors.

○ It contributes to a closed fuel cycle, potentially reducing nuclear waste generation.

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Category: **General Studies**

What is the primary fuel used in the Prototype Fast Breeder Reactor (PFBR) under construction in India?

- ○ Enriched Uranium
- ○ Mixed Oxide (MOX) fuel
- ○ Natural Uranium
- ○ Thorium

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Category: **General Studies**

A major challenge associated with FBR technology is:

- ○ The abundance of readily available fissile fuel sources.
- ○ The simplicity of their design and operation.
- ○ Concerns regarding safety and the use of plutonium.
- ○ The limited availability of fertile materials like thorium.

Prev Finish

Check Rank, Result Now and enter correct email as you will get Solutions in the email as well for future use!

Check the Result

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Restart quiz

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Mains Questions:

Question 1:

Explain the working principle of Fast Breeder Reactors (FBRs) and discuss their potential benefits and challenges for India's energy security. (250 words)

Model Answer:

Working Principle:

- Fast Breeder Reactor (FBRs) utilize fast neutrons

to fission fissile fuel (like plutonium-239) and breed more fissile fuel (plutonium-239) from fertile material (like uranium-238) through a series of nuclear reactions. This unique characteristic allows them to generate more fuel than they consume.

Benefits for India's Energy Security:

- Increased Fuel Efficiency: FBRs extract more energy from available uranium resources, reducing dependence on imports.
- Waste Reduction: They can utilize spent fuel from other reactors, minimizing radioactive waste disposal needs.
- Strategic Independence: India's abundant thorium reserves can be used in FBRs to produce fissile fuel, promoting energy independence.

Challenges:

- Technological Complexity: FBRs require advanced technology for design, construction, and operation.
- Safety Concerns: The use of plutonium and fast neutrons necessitates robust safety measures and public education.
- Economic Viability: FBR technology is still under development, and ensuring its economic competitiveness requires further research.

Question 2:

India recently achieved a milestone with the

core loading of its first indigenous Fast Breeder Reactor (PFBR). Critically analyze the significance of this development for India's energy future, considering both its potential and limitations. (250 words)

Model Answer:

- The successful core loading of the PFBR marks a significant step towards India's self-reliance in nuclear fuel production and cleaner energy generation.

Potential:

- Enhanced Fuel Security: FBRs can potentially reduce dependence on imported fissile material and utilize abundant domestic thorium reserves.
- Waste Management: They offer a way to utilize spent fuel from existing reactors, reducing the volume of radioactive waste.
- Technological Advancement: This achievement showcases India's growing expertise in advanced nuclear technology.

Limitations:

- Safety Concerns: Addressing public apprehension regarding nuclear safety is crucial for wider acceptance of FBRs.
- Economic Viability: Demonstrating the economic

competitiveness of FBR technology compared to other energy sources is essential.

- Long-term Development: Further research and development are needed to optimize FBR technology and ensure its sustainability.
- Overall, the PFBR is a significant step, but India needs to address the challenges to fully realize its potential for a cleaner and more secure energy future.

Remember: These are just sample answers. It's important to further research and refine your responses based on your own understanding and perspective.

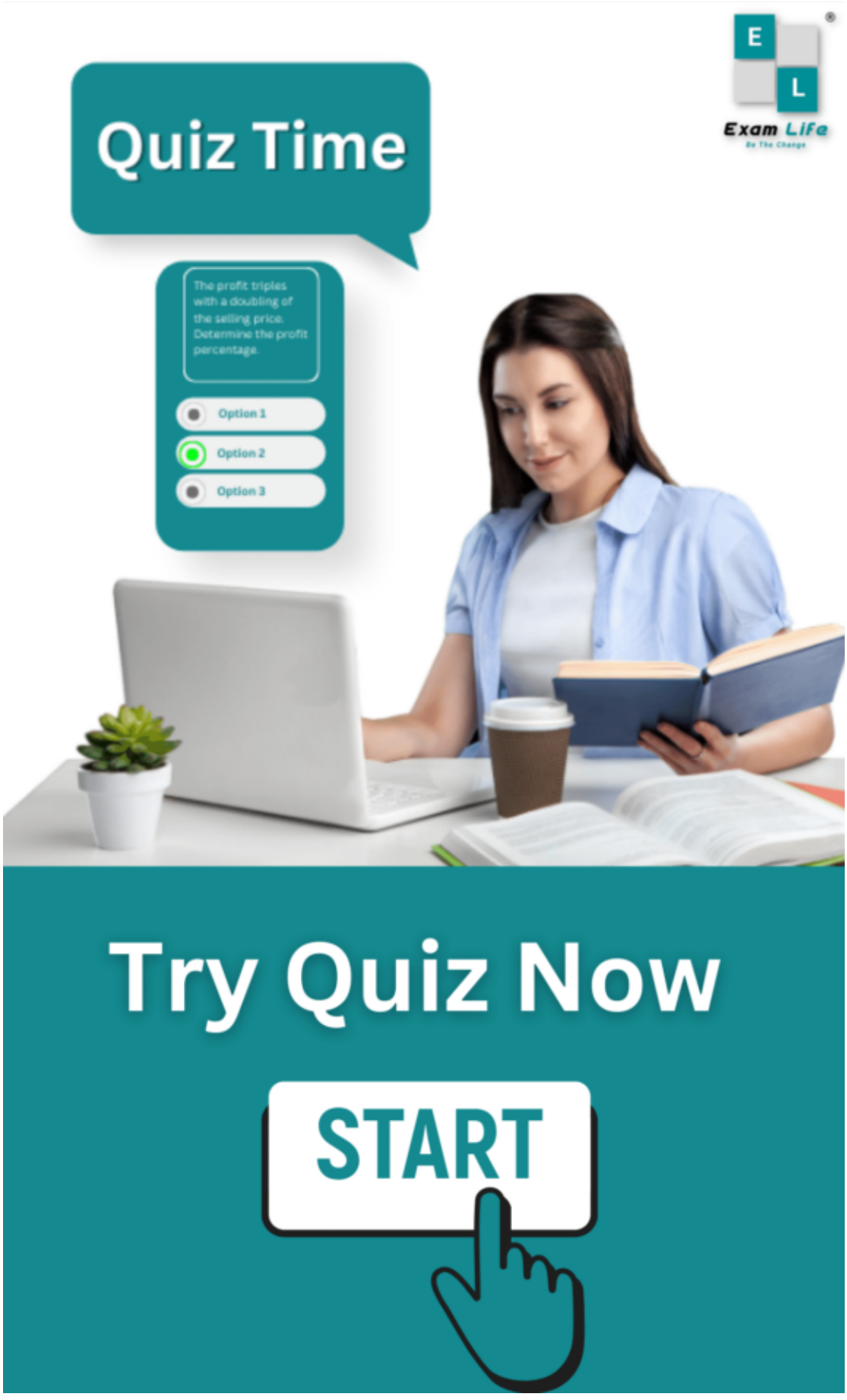
Relevance to the UPSC Prelims and Mains syllabus under the following topics:

Prelims:

- **GS 1 Paper:** Science and Tech

Mains:

- **GS Paper-II (Governance, Constitution, Public Policy):** While FBRs aren't explicitly mentioned, they can be relevant in understanding various aspects of governance:
- **Science & Technology in the service of the nation and their impacts on the economy and environment:** FBRs represent an advancement in nuclear technology with potential implications for energy security, waste management, and environmental sustainability. Discussing their potential and limitations can showcase your understanding of science and technology's role in national development.
- **Issues related to Energy Security:** FBRs hold promise for reducing dependence on imported fuel and promoting energy independence. Analyzing their potential contribution to India's energy security strategy demonstrates your awareness of contemporary energy challenges and potential solutions.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