



Nuclear Powered Trains

For Prelims: [Indian Railways \(IR\)](#), [Nuclear Power](#), [Non Fossil Fuel](#), [Solar Power](#), [Wind Power](#), [Nuclear Power Corporation of India \(NPCIL\)](#), [Small Reactors](#), [Net Zero Carbon Emission](#), [Solar Energy Corporation of India \(SECI\)](#), [Thorium Reactors](#).

For Mains: Need and Significance of Alternative Sources of Energy for Indian Railways.

Source: TH

Why in News?

[Indian Railways \(IR\)](#) is exploring the use of [nuclear power](#) through captive units as it seeks to increase reliance on [non-fossil fuel sources](#) and [renewable ones](#).

- Apart from nuclear power, the Railways is already in the process of commissioning [solar power units](#) and [wind-based power plants](#).

What are Nuclear Powered Trains?

- **About:** A [nuclear-powered train](#) uses heat generated from a **nuclear reaction** to produce high-pressure steam.
 - This steam drives **two turbines**, one turbine **powers the train**, while the other generates **electricity for equipment** like air conditioners and lights.
 - The concept of nuclear-powered trains was first seriously considered in the **1950s**, when it became an official goal of the **USSR's Ministry of Transport**.
- **Functioning of Nuclear-Powered Trains:** The proposed design involves a [portable nuclear reactor](#) that heats fluid to produce steam. This steam drives **electric turbines**, generating power for the train.
- **Safety Considerations:** The use of [thorium reactors](#) is considered due to their relatively **low radiation risk** compared to other nuclear materials. The reactor's design includes safety features to minimise risks and prevent misuse.
- **Potential Benefits:**
 - **Reduced Carbon Emissions:** Nuclear power can significantly **reduce CO2 emissions** compared to fossil fuels, aligning with global efforts to combat [climate change](#).
 - **Energy Efficiency:** Nuclear reactors provide a **high energy output** with minimal fuel. This could potentially reduce the **operational costs** and environmental impact of rail transport over long distances.
 - **Low Infrastructure Requirements:** Nuclear-powered trains could operate **independently** of overhead electric lines, reducing infrastructure costs and providing greater flexibility in operations.
 - **Extended Range:** Nuclear-powered trains could operate over **long distances** without the need for frequent **refuelling**. This would be advantageous for freight and passenger services on extensive rail networks.

- **High Efficiency:** The potential for high **operational efficiency** is a major advantage. Nuclear reactors could provide continuous power, optimising rail transport performance.
- **Challenges of Nuclear-Powered Trains:**
 - **Radiation Risks:** Handling nuclear materials and ensuring safety against **radiation leaks** are significant challenges. Adequate **shielding and safety measures** are essential to protect passengers and crew.
 - **High Costs:** The **initial costs** for developing and implementing nuclear-powered trains are **high**. This includes the expense of developing **small, safe reactors and integrating** them into locomotives.
 - **Technical Complexity:** Designing and maintaining nuclear reactors for **moving trains** involves complex engineering challenges.

How Indian Railways Plans to Reduce its Reliance on Fossil Fuel Sources?

- **Nuclear Power Exploration:** Discussions with the **Nuclear Power Corporation of India (NPCIL)** are planned to explore the use of **nuclear power**.
 - Indian Railways is looking to have its own captive use power plants, **small reactors**, captive power generating units and so on.
- **Net Zero Carbon Emission Target:** The Railways plans to become a **net zero carbon emitter by 2030**. For it, IR will need **30,000 MW** of renewable capacity by **2029-30**.
- **Current Renewable Energy Efforts:** For use of renewables, the Railways is exploring partnerships with **Solar Energy Corporation of India (SECI)**, NTPC, the Ministry of New and Renewable Energy (MNRE), among others.
- **Renewable Energy Achievements:** In 2023, about **147 MW of solar plants** (both on rooftops and on land) and about **103 MW of wind power plants** have been commissioned.
 - Railways has electrified nearly **63,500 Kilometres** till FY24, or over **96%** of the total broad-gauge network.
 - **2,637 stations** and service buildings have been provided with **solar roof-top plants** with a total power generation capacity of **177 MW**.

Why Indian Railways Need Alternative Sources of Energy?

- **High Energy Consumption:** The Indian Railways consumes over **20 billion kWh** of electricity annually, which is **around 2%** of the country's total power consumption.
 - This high level of consumption underscores the need for more **sustainable energy** solutions.
- **Increasing Power Demand:** Power requirements are projected to **grow** from **4,000 MW in 2012** to approximately **15,000 MW by 2032** due to ongoing electrification efforts.
 - This substantial increase highlights the need for **diversified energy** sources.
- **Electrification Targets:** Indian Railways aims to electrify **100%** of its broad-gauge network by **2030**. This ambitious goal will significantly increase the demand for electricity, necessitating alternative energy sources to meet this need sustainably.
- **Environmental Impact:** The railway's reliance on **diesel and electricity** results in high CO2 emissions.
 - As a part of its **low-carbon strategy**, the Indian railways has envisaged a target of **33% reduction** in its emissions intensity below 2005 levels by **2030**.
- **Diminishing Revenue Surplus:** Railways' revenue earnings have barely been able to keep up with its revenue expenditure.
 - Between **2013-14 and 2023-24**, Railways' revenue expenditure is estimated to grow at an annualised rate of **7.2%**, faster than its revenue receipts (annual growth of **6.3%**).
 - Indian Railways aims to **generate its own energy** to reduce its expenditure on outside energy sources.
- **Cost Optimisation:** Indian Railways is the **largest consumer of electricity and spends close to Rs 20,000 crore annually** to run their trains and offices.
 - The organisation is **looking to reduce costs through renewable energy** procurement and lower-cost models for power generation.

Conclusion

The need for alternative sources of energy for Indian Railways is driven by several **critical factors** like high energy consumption and costs, increasing power demand due to electrification, environmental impact, and the necessity for energy security and cost management. While the concept of **Nuclear Powered Trains** holds promise for reducing carbon emissions and improving efficiency, significant hurdles related to **safety, cost, and public acceptance** must be addressed. As research continues and technology advances, nuclear propulsion may play a role in the future of rail transport.

Drishti Mains Question:

Discuss the need for alternative sources of energy for Indian Railways? How nuclear energy can help railways become a net zero carbon emitter by 2030?

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. In the Indian context, what is the implication of ratifying the 'Additional Protocol' with the 'International Atomic Energy Agency (IAEA)'?(2018)

- (a) The civilian nuclear reactors come under IAEA safeguards.
- (b) The military nuclear installations come under the inspection of IAEA.
- (c) The country will have the privilege to buy uranium from the Nuclear Suppliers Group (NSG).
- (d) The country automatically becomes a member of the NSG.

Ans: (a)

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. The setting up of a Rail Tariff Authority to regulate fares will subject the cash strapped Indian Railways to demand subsidy for obligation to operate non-profitable routes and services. Taking into account the experience in the power sector, discuss if the proposed reform is expected to benefit the consumers, the Indian Railways or the private container operators. (2014)

Q. Describe the benefits of deriving electric energy from sunlight in contrast to conventional energy generation. What are the initiatives offered by our government for this purpose? (2020)

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

