India Launches Its First Hydrogen-Powered Train to Promote Green Rail Mobility and Advance Clean Transportation Technologies

Published On: 20-07-2026

Recent Developments:

- **Prime Minister Narendra Modi** flagged off **India's first hydrogen-powered train** on the **89 km Jind–Sonipat section** in Haryana under the **Delhi Division of Northern Railway**.
- **The project**, developed by the **Integral Coach Factory (ICF), Chennai**, marks India's entry into hydrogen-based railway transportation and supports the country's transition towards low-carbon and sustainable mobility. It is among the world's most powerful hydrogen fuel-cell trainsets with a **1200 kW** propulsion system.

India's First Hydrogen-Powered Train:

About:

- **The train** is India's first **hydrogen fuel cell-powered train**, designed to replace diesel traction on selected non-electrified railway routes.
- **The trainset** has been developed by the **Integral Coach Factory (ICF), Chennai**, under the Ministry of Railways.
- **The train** consists of **10 coaches**, including **2 Hydrogen Driving Power Cars (DPCs)** and **8 Trailer Coaches (TCs)**.
- **The propulsion system** is powered by a **1200 kW Hydrogen Fuel Cell System**, making it one of the most powerful hydrogen-powered trainsets globally.
- **The train** is approved for an operational speed of **75 kmph**, while its design speed is **110 kmph**.

Major Components of the Hydrogen Train:

Proton Exchange Membrane (PEM) Fuel Cells:

- **The Proton Exchange Membrane (PEM) Fuel Cell** converts hydrogen directly into electrical energy through an electrochemical reaction.
- **The fuel cell** supplies electricity continuously without combustion, improving energy efficiency and eliminating direct carbon emissions.

Lithium Iron Phosphate (LFP) Batteries:

- **Lithium Iron Phosphate (LFP) batteries** store surplus electrical energy generated by the fuel cells.
- **The batteries** provide additional power during acceleration, peak load conditions and regenerative braking operations.

Hydrogen Storage System:

- **Compressed hydrogen gas** is stored in specially designed high-pressure cylinders installed within the train.
- **The storage system** ensures continuous hydrogen supply to the fuel cell under varying operating conditions.

Electric Traction Motors:

- **Electric traction motors** convert electrical energy into mechanical energy to propel the train.
- **The traction system** delivers smooth acceleration, higher energy efficiency and lower maintenance requirements than conventional diesel locomotives.

Working Mechanism of Hydrogen Fuel Cell Train:

Basic Principle:

- **A hydrogen-powered train** generates electricity onboard using hydrogen instead of diesel fuel or electricity supplied through overhead electric lines.
- **The train** functions as a **Fuel Cell Electric Train (FCET)**, where electricity is produced within the train itself.

Electrochemical Process:

- **The primary power source** is the **Proton Exchange Membrane Fuel Cell (PEMFC)**.
- **Hydrogen** supplied from storage cylinders reacts with **oxygen** obtained from atmospheric air across a **Proton Exchange Membrane**, generally made of **Perfluorosulfonic Acid (PFSA)** polymer.
- **The electrochemical reaction** separates hydrogen into protons and electrons, generating electricity while allowing protons to pass through the membrane.
- **The electrons** travel through an external electrical circuit, producing usable electric current for train propulsion.
- **The only reaction products** are **water vapour** and **heat**, making the technology a zero tailpipe emission system.
- **The generated electricity** powers the traction motors and simultaneously charges onboard batteries whenever surplus energy is available.

Safety Features:

Hydrogen Safety Systems:

- **Hydrogen leak detectors** continuously monitor hydrogen production, storage and dispensing facilities.
- **Flame detection systems** provide continuous surveillance to identify accidental ignition at the earliest stage.
- **High-pressure storage cylinders** are designed according to stringent engineering and railway safety standards.
- **Multiple safety protocols** minimise operational risks associated with handling highly flammable hydrogen.

Advantages of Hydrogen-Powered Trains:

Environmental Benefits:

- **Hydrogen fuel cell technology** produces only water vapour and heat during operation.
- **The technology** eliminates direct emissions of carbon dioxide, sulphur oxides, nitrogen oxides and particulate matter.
- **The train** offers a sustainable transport solution for non-electrified railway routes where complete electrification is not economically viable.

Energy Efficiency:

- **Fuel cell systems** exhibit higher conversion efficiency than conventional diesel engines.
- **Battery integration** improves overall energy utilisation through regenerative braking and energy storage.

Operational Benefits:

- **Hydrogen trains** reduce dependence on imported fossil fuels.
- **The technology** lowers long-term maintenance requirements because fuel cells contain fewer moving mechanical components.
- **The train** operates with significantly lower noise and vibration levels than diesel-powered trains.

Significance for India:

Sustainable Mobility:

- **The project** supports decarbonisation of India's railway transport sector by replacing diesel traction with zero tailpipe emission technology.
- **Hydrogen-powered trains** provide a viable clean transport alternative for non-electrified railway corridors.

Climate Commitments:

- **The initiative** contributes towards India's commitment to achieve **Net Zero emissions by 2070**.
- **The project** complements national clean energy and low-carbon transportation policies.

Technological Advancement:

- **The successful deployment** places India among the leading countries developing high-capacity hydrogen-powered railway systems.
- **The project** strengthens indigenous capabilities in fuel-cell technology, hydrogen storage and advanced railway engineering.

Energy Security:

- **Hydrogen-based transportation** diversifies India's transport energy mix.
- **Domestic production of Green Hydrogen** can reduce long-term dependence on imported petroleum products.

Challenges in Hydrogen Rail Transportation:

Hydrogen Infrastructure:

- **India** currently has limited infrastructure for hydrogen production, compression, transportation, storage and refuelling.
- **Large-scale adoption** requires establishment of an integrated hydrogen supply chain.

High Capital Cost:

- **Hydrogen production plants, refuelling stations, fuel-cell systems and specialised rolling stock** require substantial initial investment.
- **The current cost** of green hydrogen remains significantly higher than conventional transport fuels.

Safety Challenges:

- **Hydrogen** is highly flammable and requires specialised storage technologies and rigorous operational safety standards.

- **Continuous monitoring systems** are essential to prevent leakage and accidental ignition.

Technology Maturity:

- **Fuel-cell systems** still require further improvements in durability, cost reduction and long-term operational reliability.

Hydrogen:

Properties:

- **Hydrogen** is the chemical element represented by the symbol **H** with **Atomic Number 1**.
- **Hydrogen** is the lightest and most abundant chemical element in the universe, constituting nearly **75%** of normal matter by mass.
- **Hydrogen** is a colourless, odourless, tasteless, non-toxic and highly inflammable gas.
- **Hydrogen** possesses one of the highest energy contents per unit mass among all known fuels.

Types of Hydrogen:

- **Grey Hydrogen:** Produced from fossil fuels without carbon capture, resulting in significant carbon emissions.
- **Blue Hydrogen:** Produced from fossil fuels with **Carbon Capture, Utilisation and Storage (CCUS)** technology.
- **Green Hydrogen:** Produced through electrolysis using renewable electricity with negligible greenhouse gas emissions.
- **Pink Hydrogen:** Produced through electrolysis powered by nuclear energy.
- **Turquoise Hydrogen:** Produced through methane pyrolysis, generating solid carbon instead of carbon dioxide.

Related Government Initiatives:

National Green Hydrogen Mission:

- **Launched in 2023**, the mission aims to establish India as a global hub for production, utilisation and export of **Green Hydrogen**.
- **The mission** targets production of at least **5 Million Metric Tonnes (MMT)** of Green Hydrogen annually by **2030**, supported by around **125 GW** of additional renewable energy capacity.

Indian Railways Net Zero Target:

- **Indian Railways** aims to become a **Net Zero Carbon Emitter by 2030** through complete electrification, renewable energy integration and adoption of alternative clean fuels.

UPSC Value Addition:

Important Terms:

- **Fuel Cell:** An electrochemical device that converts chemical energy directly into electrical energy without combustion.
- **Proton Exchange Membrane Fuel Cell (PEMFC):** A fuel cell that uses a proton-conducting polymer membrane to generate electricity from hydrogen and oxygen.

- **Perfluorosulfonic Acid (PFSA):** A specialised polymer membrane used for proton conduction in PEM fuel cells.
- **Lithium Iron Phosphate (LFP):** A lithium-ion battery chemistry known for high thermal stability, long cycle life and enhanced safety.
- **Green Hydrogen:** Hydrogen produced through electrolysis powered entirely by renewable energy sources.

Prelims Facts:

- **India's first hydrogen-powered train** operates on the **Jind–Sonipat** section of **Northern Railway**.
- **The train** has been developed by the **Integral Coach Factory (ICF), Chennai**.
- **The propulsion system** has a capacity of **1200 kW**.
- **The trainset** consists of **2 Hydrogen Driving Power Cars** and **8 Trailer Coaches**.
- **The operational speed** is **75 kmph**, while the **design speed** is **110 kmph**.
- **The primary energy conversion technology** is the **Proton Exchange Membrane Fuel Cell (PEMFC)**.
- **The only tailpipe emissions** from hydrogen fuel cell operation are **water vapour** and **heat**.
- **The National Green Hydrogen Mission** targets **5 Million Metric Tonnes** of annual Green Hydrogen production by **2030**