India's First Hydrogen Fuel Cell Train Set to Redefine Sustainable Rail Mobility with Capacity of Around 2,600 Passengers

The Smokeless Magic of Hydrogen Helps Build a Greener Indian Railways as It Powers the New-Era Train

With Multi-layer Safety Systems Detecting Hydrogen Leaks, Heat, Flames and Smoke, the Train Is Certified as Safe

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Indian Railways is set to flag off India's first Hydrogen Fuel Cell Trainset, a train that generates its own electricity onboard using hydrogen, the cleanest fuel known. It produces near-zero emissions at the point of use. This milestone marks the latest chapter in the evolution of how Indian Railways has powered its trains, reflecting India's broader journey from coal and steam to cleaner, more sustainable sources of energy.

Over the past 12 years, rapid electrification has significantly reduced dependence on imported diesel, paving the way for the next leap in clean rail mobility. Today, with over 99% of Broad Gauge routes electrified, Indian Railways is taking that journey a step further. Unlike conventional electric trains that draw power from overhead lines, the Hydrogen Fuel Cell Trainset generates electricity onboard through a chemical reaction between hydrogen and oxygen, with water vapour as its only by-product.

In a sense, the train once again carries its own source of power, as steam and diesel locomotives once did. But instead of burning traditional fuels such as coal or diesel, hydrogen generates electricity inside the train using oxygen from the atmosphere, eliminating combustion and dependence on an external power supply. As electricity is generated onboard through clean hydrogen technology, the train represents the greenest form of rail propulsion, powering the future of sustainable mobility. To complement this advanced propulsion system, India has equipped the train with multi-layer safety systems capable of detecting hydrogen leaks, heat, flames and smoke. With an operational speed of 75 kmph on the Jind–Sonipat section and a design speed of 110 kmph, the train is not only safer but also faster on this 89 km route.

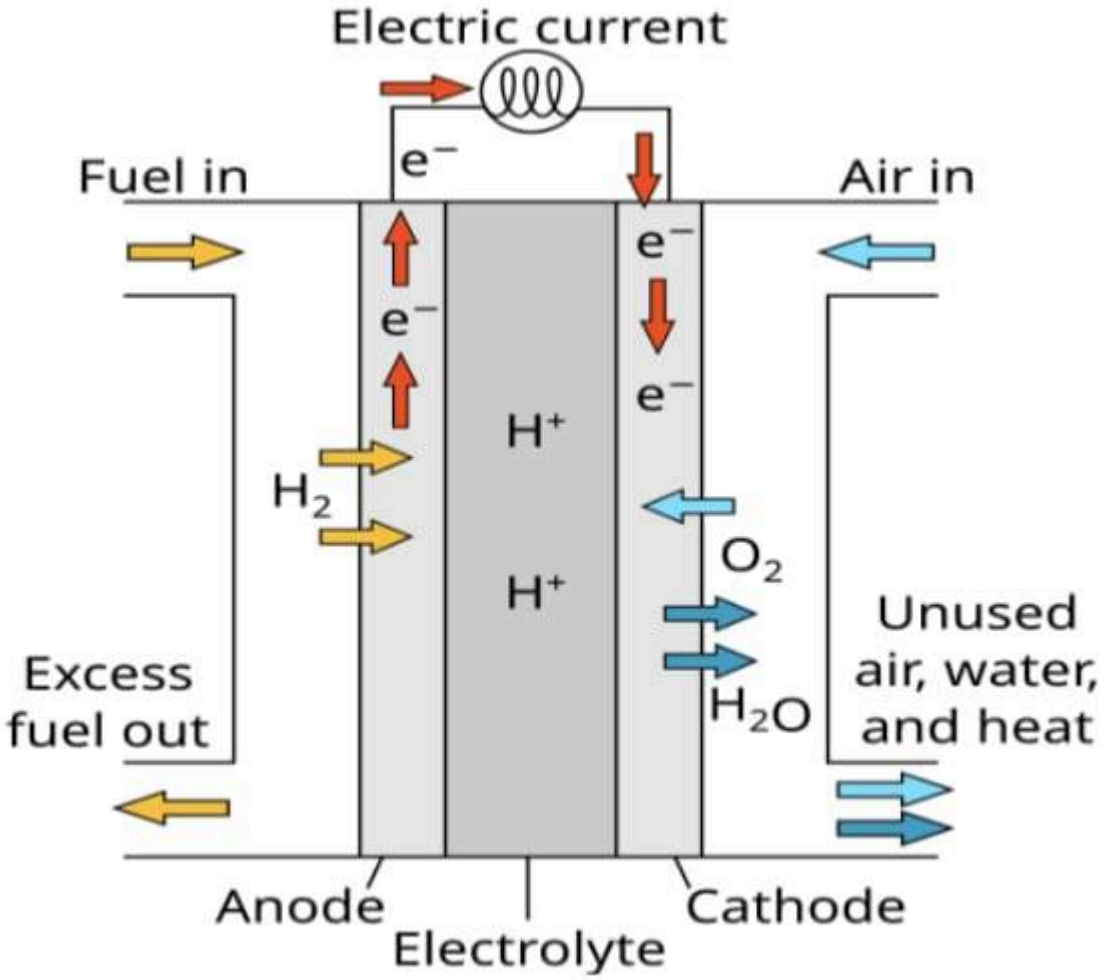
Most hydrogen passenger trains currently operating globally comprise only two or three coaches and are primarily deployed on short regional routes. In contrast, the Indian Railways trainset has been configured as a 10-coach passenger train with a capacity of around 2,600 passengers, demonstrating the scalability of hydrogen-powered rail transport for high-capacity passenger operations.

But hydrogen is famously flammable, and that naturally raises a question in everyone's mind: is it safe to put thousands of passengers on a train running on a gas that can catch fire so easily? Here is a simple explanation of how the train works, and everything Indian Railways has done to make it safe.

How Does a Hydrogen Train Actually Work?

Unlike conventional diesel locomotives that burn fuel to generate mechanical power, a hydrogen train carries a small power plant onboard in the form of a Proton Exchange Membrane (PEM) fuel cell. Hydrogen stored in the train's cylinders combines with oxygen from the surrounding air inside the fuel cell, producing electricity that powers the traction motors and turns the wheels. The only direct by-products of this electrochemical reaction are water vapour and heat. There is no combustion, no smoke and no tailpipe carbon emissions.

In simple terms, the process is almost like magic: Hydrogen + Oxygen → Electricity + Water Vapour → The Train Moves. What appears to be magic is actually clean science at work, converting hydrogen directly into electricity inside the train. The only direct by-product is water vapour. There is no smoke or direct carbon emission, contributing to a greener Indian Railways.



The train consists of two Hydrogen Driving Power Cars (DPCs) and eight Trailer Coaches (TCs). Each DPC houses fuel cells, lithium iron phosphate (LFP) batteries and hydrogen storage cylinders that work together to provide traction power while ensuring reliable operation under varying operating conditions.

Hydrogen Fuel Cell Power Car and TCs' - Exterior

DPC

TCs

The two power cars, one at each end, produce 1,200 kW (1600 hp) of power per DPC, together enough to push the entire train up to 110 km/h. The Hydrogen Fuel Cell Powered Train will initially operate on the Jind–Sonipat section of Northern Railway, connecting Jind Junction, Gohana Junction and Sonipat while serving intermediate stations and proposed halts including Jind City, Pandu Pindara Junction, Lalit Khera Halt, Bhambhewa, Isapur Kheri Halt, Butane Halt, Khandrai Halt, Rabrah Halt, Lath Halt, Mohana, Barwasni Halt and Sonipat New.

The route has been selected for demonstrating the operational viability, safety and reliability of hydrogen-powered passenger train services under regular operating conditions. The dedicated hydrogen storage, compression and dispensing facility established at Jind will support refuelling operations, creating India's first integrated hydrogen railway ecosystem.

Where Does Hydrogen Come From? The Refuelling Station at Jind

Just like a petrol pump or a CNG station, the train needs a place to refuel, and Indian Railways has established India's largest railway hydrogen refuelling facility for this purpose at Jind in Haryana. The facility operates in three stages.

First, hydrogen is produced on site through electrolysis, in which water is split into hydrogen and oxygen using electricity at the green hydrogen plant, and is then stored safely in dedicated storage tanks. Second, the hydrogen is compressed to 500 bar, enabling a larger quantity to be stored in a smaller volume. Finally, it is dispensed through two independent hydrogen dispensers at a regulated pressure of 350 bar, allowing both Hydrogen Driving Power Cars to be refuelled simultaneously and reducing turnaround time.

The facility stores nearly 3,000 kg of hydrogen at a time, sufficient to support regular operations of the trainset, and its storage and supply system has been approved by the Petroleum and Explosives Safety Organisation (PESO).

Building Indigenous Capabilities

Designed, engineered and integrated in India, the train has been developed using indigenous technology, reflecting the country's growing capabilities in advanced railway engineering.

India’s first Hydrogen Fuel Cell Powered Trainset has been developed under the leadership of Indian Railways, with Research Designs and Standards Organisation (RDSO) formulating the technical specifications and leading the design approval process. The trainset has been integrated by M/s Medha Servo Drives, while Integral Coach Factory (ICF) contributed to the train’s theme and exterior design.

Complementing the rolling stock, Indian Railways has established a complete hydrogen ecosystem at Jind, comprising hydrogen production through electrolysis, storage, compression and dispensing infrastructure to support train operations.

What Exactly Is Hydrogen, and Why Does It Worry People?

In simple terms, hydrogen is colourless, so you cannot see it, and odourless, so you cannot smell it. It is also tasteless. It is non toxic, meaning it will not poison you if you are near it. The part that makes people nervous, and rightly so, is that it is highly inflammable and needs to be handled with real care. Because hydrogen cannot be seen or smelled, the entire safety design of this project is built around one goal, which is to detect even the smallest leak instantly and never let it turn into a danger.

So How Is Safety Actually Ensured?

Safety has been built into every layer of the project. From the design of the train and hydrogen storage cylinders to refuelling infrastructure, monitoring software and emergency response systems. Rather than depending on a single protective measure, Indian Railways has adopted the internationally accepted principle of defence in depth, where multiple independent safety systems continuously monitor, verify and protect every stage of hydrogen storage, transfer and utilisation.

Detection happens everywhere. The train and the plant are fitted with devices that continuously watch for hydrogen leaks, unusual heat, flames, or smoke, so any problem is caught within seconds. On top of this, non-stop ventilation keeps air moving through the train at all times, so that even if a tiny amount of hydrogen were to leak, it gets safely carried away and diluted in the open air instead of collecting anywhere.

There is also an automatic shut off system. If anything unusual is detected, the system can automatically cut off the hydrogen supply on its own, without waiting for a person to react. Loco Pilot safety has been given particular attention too. The Loco Pilot’s cabin has been specifically designed to keep the Loco Pilot safe, with a special mode that allows the train to be moved to safety in an emergency, and a screen that shows the Loco Pilot the real health of the whole system at all times.

The Jind hydrogen plant itself has similar protections, including leak detectors, flame detectors, automatic shutdown systems, water sprays to control any fire, and fire alarms, all working together.

Checked and Approved, Not Just by Indian Railways

The hydrogen ecosystem has been designed in accordance with internationally accepted standards, including NFPA-2 and the ISO 19880 Series, while also complying with the statutory requirements of the Petroleum and Explosives Safety Organisation (PESO). Before commissioning, the entire system underwent an independent third-party safety assessment by TÜV SÜD, Germany, one of the world's leading technical inspection and certification agencies.

The Testing the Train Went Through Before Carrying Passengers

Before this train was cleared to run, it was put through a series of demanding tests to make sure everything works exactly as intended. Load box testing checked that the electrical and power systems perform correctly under real load. Radio frequency trials made sure the train's electronics do not interfere with other signalling and communication systems. Oscillation trials checked that the train runs smoothly and stably at speed, without excessive shaking. Emergency brake distance trials confirmed exactly how

quickly and safely the train can stop in an emergency. Only after successfully completing these evaluations, along with statutory inspections and independent safety assessments, was the project considered ready for operational deployment.

Where Does India Stand Globally?

Hydrogen-powered trains are still at a nascent stage globally. Germany became the first country to introduce commercial hydrogen passenger trains, while France, Italy, China, Japan and a few other countries are pursuing pilot projects or limited deployments. However, these trains typically comprise two to four coaches and are intended primarily for regional passenger services.

India's Hydrogen Fuel Cell Trainset represents a significant advancement in both scale and ambition. Beyond the train itself, India has also established the country's largest railway hydrogen refuelling facility at Jind, creating a complete hydrogen rail ecosystem encompassing rolling stock, storage, dispensing infrastructure, safety systems and operational protocols.

Future of Hydrogen Trains

Indian Railways is also exploring the deployment of hydrogen technology on heritage railways, including the Kalka–Shimla route, by leveraging the experience gained through the Jind–Sonipat Hydrogen Train project.

These initiatives signal Indian Railways' transition from a pioneering pilot project to a structured national programme for hydrogen-powered rolling stock, reinforcing India's leadership in sustainable mobility while contributing to the National Green Hydrogen Mission and the country's long-term Net Zero goal.

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