India’s First Hydrogen-Powered Train

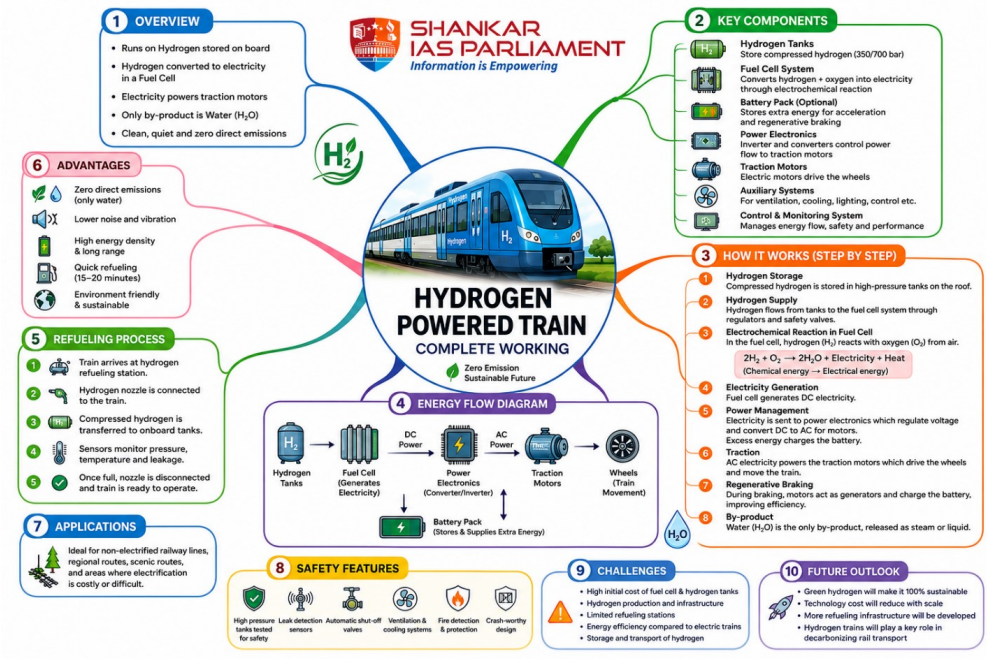
Mains: *GS III –Infrastructure*

Why in News?

India has entered a new era of green railway transportation with the launch of its first hydrogen-powered train on the 89-km Jind–Sonipat section in Haryana, flagged off by Prime Minister Narendra Modi on 17 July 2026.

What is a Hydrogen-Powered Train?

- **Hydrogen-powered train** – It is a self-propelled train that generates electricity onboard using hydrogen fuel instead of relying on overhead electric lines or diesel engines.
- Unlike conventional diesel locomotives that burn fuel to generate mechanical power, a hydrogen train carries a small onboard power plant in the form of a **Proton Exchange Membrane (PEM) fuel cell**.
- Inside the fuel cell, hydrogen combines with oxygen from the surrounding air through an electrochemical reaction to generate electricity.
- This electricity powers the traction motors that drive the wheels.
- The only direct by-products of this process are **water vapour and heat**, making hydrogen trains a zero tailpipe emission mode of transport with no smoke or carbon emissions during operation.



What are the key features of India's first hydrogen train?

- **Coaches** – India's first hydrogen-powered train is a **ten-coach trainset** comprising:
  - Two Hydrogen Driving Power Cars (DPCs)
  - Eight Trailer Coaches (TCs)
- **Passenger capacity** – The train has the capacity to carry approximately **2,600 passengers**, with seating for around **682 passengers**.
- **Specifications** – Some of its important specifications include:
- **Route** – Jind–Sonipat (89 km), Haryana
- **Operational speed** – 75 km/h
- **Design speed** – 110 km/h
- **Trips** – Two round trips per day
- **Daily distance covered** – 356 km
- **Hydrogen consumption** – Approximately 300 kg per day
- The train is regarded as one of the **world's longest hydrogen-powered passenger trainsets** with eight passenger coaches and two driving power cars.
- It is also among the most powerful hydrogen trainsets globally with a total installed power of **2400 kW**.
- **Working of the Hydrogen Fuel Cell System –** The train operates using an onboard hydrogen-electric propulsion system.
- Each Driving Power Car houses:
  - Hydrogen fuel cells
  - Lithium Iron Phosphate (LFP) batteries
  - High-pressure hydrogen storage cylinders
- **Power packs** – Each power car contains four integrated power packs, each producing 300 kW of power.
- Every power pack consists of:
  - **115 kW generated by the hydrogen fuel cell**
  - **185 kW supplied by the Lithium Iron Phosphate battery**
- **Power generated** – Each Driving Power Car generates **1200 kW**, and together the two power cars produce **2400 kW (approximately 3200 hp)**, comparable to conventional Electrical Multiple Units (EMU) and Diesel Electric Multiple Units (DEMU) operating on similar routes.
- The fuel cell continuously combines hydrogen stored onboard with oxygen from the atmosphere to generate electricity. Unlike internal combustion engines, this process involves no burning of fuel.
- **Role of the Battery System –** The hydrogen fuel cell provides a **constant power output**, whereas the train's power requirement varies depending on acceleration, cruising speed, and braking.
- The battery complements the fuel cell as follows:
- During train start-up, power demand is relatively low.
- The surplus electricity generated by the fuel cell is used to charge the battery.
- As the train accelerates and reaches higher speeds, power demand increases.
- The battery supplements the fuel cell by supplying additional electricity.
- While approaching stations or during low-power operation, battery discharge stops and the excess electricity from the fuel cell again charges the battery.

- Consequently, after completing a journey, the battery remains nearly **80% charged**, ensuring efficient energy management and reducing energy wastage.
- The hydrogen fuel cell used in the train has been imported from the Canadian company **Ballard**, which specializes in fuel cell technology.

What is the process for hydrogen production, storage and refuelling?

- **Hydrogen Production –** Hydrogen is produced onsite through **electrolysis**, wherein electricity splits water into hydrogen and oxygen. The hydrogen generated at the green hydrogen plant is stored in dedicated storage tanks.
- **Hydrogen Compression –** Since hydrogen occupies a large volume, it is compressed to approximately **500 bar**, allowing a larger quantity of gas to be stored in a smaller space.
- **Refuelling –** Hydrogen is dispensed to the train at a regulated pressure of **350 bar** through **two independent dispensers**, enabling both Driving Power Cars to be refuelled simultaneously and reducing turnaround time.
- The Jind facility has a storage capacity of nearly **3,000 kg of hydrogen**, sufficient for regular train operations.
- It has also been approved by the **Petroleum and Explosives Safety Organisation (PESO)**.
- Additionally, a **chiller plant** maintains hydrogen at approximately **–15°C during dispensing**, facilitating efficient refuelling.
- **Safety Measures –** Hydrogen is colourless, odourless, tasteless, non-toxic, but **highly inflammable**, requiring stringent safety systems.
- Since hydrogen leaks cannot be detected by human senses, the train incorporates multiple layers of safety.
- The train and hydrogen plant are equipped with:
    - Continuous hydrogen leak detection systems
    - Flame detectors
    - Heat sensors
    - Smoke detectors
    - Continuous ventilation systems
    - Automatic hydrogen shut-off mechanisms
    - Fire alarms
    - Water spray systems for fire control
    - The train also includes a specially designed **Loco Pilot cabin** featuring:
    - Real-time monitoring of the health of the hydrogen system
    - Emergency operating mode enabling the train to be safely moved in case of an incident
- Before commissioning, the complete hydrogen system underwent an independent third-party safety assessment by **TÜV SÜD, Germany**, one of the world's leading technical inspection and certification agencies.
- **Development of the Project –** The hydrogen train project was initiated by **Northern Railway** during **2020–21** at an estimated cost of **₹136 crore**.
- Implementation began in **April 2022** after awarding the contract to **Medha Servo Drives**, Hyderabad.
- **Institutions involved** – The project involved multiple institutions:

    - **Research Designs and Standards Organisation (RDSO)** formulated technical specifications and led the design approval process.
    - **Medha Servo Drives** integrated the hydrogen propulsion system.
    - **Integral Coach Factory (ICF)** designed the train's theme and exterior.
- Following successful trials, the **Ministry of Railways** sanctioned commercial operation on **22 May 2026**.

What is the global status of hydrogen trains?

- **Germany** – It became the **first country to introduce commercial hydrogen passenger trains** when Alstom launched the **Coradia iLint** in 2018 after first presenting the technology in Berlin in 2016.
- **Other countries** – Countries including, France, Italy, China, Japan, and United States have launched pilot projects or limited hydrogen train services.
- However, most hydrogen trains worldwide consist of only **two to four coaches** and are primarily used for regional passenger services over relatively short distances.
- In comparison, India's ten-coach hydrogen train represents one of the longest and most powerful hydrogen trainsets developed so far.

What are the future prospects?

- **Expansion** – Indian Railways intends to use the experience gained from the Jind–Sonipat project to expand hydrogen technology to other railway routes.
- The Railways is exploring the deployment of hydrogen-powered rolling stock on **heritage railways**, including the **Kalka–Shimla route**.
- **Long-term objective** – It is to transition from a pilot project to a structured national programme for hydrogen-powered trains, supporting:
    - Decarbonisation of railway transport
    - National Green Hydrogen Mission
    - Energy security
    - Sustainable mobility
    - India's Net Zero commitments
- The future expansion of hydrogen trains will depend on the operational performance, economic viability, and reliability of the first hydrogen train.

What lies ahead?

- India's first hydrogen-powered train represents a landmark achievement in clean transportation and railway innovation.
- By replacing diesel-based propulsion with hydrogen fuel cells and battery technology, the train demonstrates a zero-emission alternative capable of delivering performance comparable to conventional trains.
- The project marks a significant milestone in the evolution of Indian Railways—from coal and steam locomotives to diesel, electric traction, and now hydrogen-based propulsion.
- The hydrogen train is a major step towards clean mobility and aligns with India's commitment to sustainable transportation, the National Green Hydrogen Mission, and

the long-term Net Zero target.

- It also places India among a small group of countries that have successfully deployed hydrogen-powered passenger trains.
- The establishment of indigenous hydrogen infrastructure, robust safety mechanisms, and successful integration of advanced fuel cell technology reflects India's growing capabilities in sustainable transport.

References

1. The Hindu| India's 1st Hydrogen Powered Train
2. News on Air| PM Flags Hydrogen Train