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Special Edition – April 2026

Path to Sustainability

Harnessing Hydrogen

Recent developments

Curated and summarized - Industry and Patent news

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Preface

There is a major transformation taking place in the global energy landscape as countries try to reduce carbon emissions and mitigate the impact of climate change. Hydrogen, a clean and versatile energy carrier, is emerging as a promising solution for a sustainable future. Its applications are diverse, ranging from powering vehicles and generating electricity to fueling industrial processes. The hydrogen ecosystem is rapidly evolving, with innovations emerging across the entire value chain.

This monthly report is focused on **"Hydrogen as a fuel"** including applications in transportation, manufacturing industries and energy sector. This report is a free resource for anyone working in this domain including technologists, innovators, Intellectual Property (IP) managers, strategy makers, environmental enthusiasts, etc. The report contains curated insights and summaries of the latest news and key patents published in the last one month, including the latest products, business updates, collaborations, new innovations, and more.

This special edition report examines how Artificial Intelligence (AI) is emerging as a foundational enabler of scalability, efficiency, and reliability across the hydrogen ecosystem.

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Special Edition

This special edition report examines how Artificial Intelligence (AI) is reshaping the hydrogen ecosystem by enabling real-time optimization, reducing operational risk, and accelerating large-scale deployment. As hydrogen systems grow more complex, AI is emerging as a foundational capability, improving efficiency, reliability, and cost competitiveness across the value chain and strengthening the commercial viability of hydrogen projects worldwide. This month's report explores where AI innovation is most concentrated, how it is being applied, and what it signals for the future competitiveness of the global hydrogen ecosystem.

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Key Insights this month

- AI is not an add-on, it is the enabler of scalable hydrogen. Scale will be driven not by molecule production efficiency alone, but by intelligent system operation, giving early AI adopters a lasting advantage in efficiency, asset utilization, and speed of scale-up.

- AI innovations are more visible in the application layer (End-Use) of the hydrogen ecosystem compared with Storage and Distribution. This reflects the higher system complexity at end-use, while Storage and Distribution currently apply AI mainly for transport planning and facility monitoring rather than full autonomous control.

- China's leadership in AI-driven hydrogen innovation reflects a coordinated research-to-deployment model, where academic research, industrial application, and national priorities are tightly integrated, accelerating system-level learning and execution.

- Asahi Kasei's deployment of containerized electrolyzers enables localized, demand-driven hydrogen supply, significantly reducing logistics complexity. This localized production model accelerates the commercial rollout of hydrogen refueling networks, particularly in early-stage and challenging operating environments.

- Toyota's entry alongside Daimler Truck and Volvo shifts fuel-cell development from company-led innovation to a shared industrial platform, accelerating standardization, scale, and cost reduction in heavy-duty hydrogen mobility.

- AI-driven patent innovation is advancing across the hydrogen ecosystem. Current applications include defect and contamination detection in fuel-cell systems and machine-learning-based flow-field design in PEM fuel cells. Digital-twin-enabled thermal management is also emerging as a key application for solid-state hydrogen storage in fuel-cell vehicles.

Use of Artificial Intelligence (AI) in Hydrogen Ecosystem

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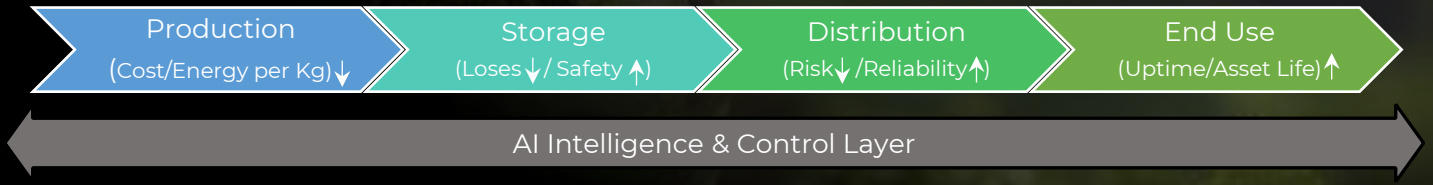
How AI is Reshaping the Hydrogen Ecosystem

Why AI is required

AI is emerging as a system-level enabler to unlock cost, efficiency, reliability, and scalability.

How AI can benefit the Hydrogen Ecosystem

AI enables real-time optimization across the hydrogen value chain, improving efficiency, reliability, cost competitiveness, and enabling scalable deployment. It transforms hydrogen assets from static infrastructure into adaptive, self-optimizing systems.



- AI-based Electrolyser optimization
- Renewable energy load balancing
- Digital Twins for plant performance
- Predictive Maintenance for Stacks
- Failure prediction using sensor data

- Storage Optimization
- Inventory forecasting
- Boil-off loss minimization
- Safety & Leak detection
- Condition Monitoring

- Route optimization
- Pipeline monitoring and anomaly detection
- Fleet/Logistics Planning
- Demand Forecasting & Network Balancing

- Smart Grid Integration
- Refueling station optimization
- Real-time anomaly detection
- Safety monitoring
- Predictive maintenance of Fuel Cells

The hydrogen transition is not only limited by production, but also by how intelligently we operate hydrogen systems in the real world.

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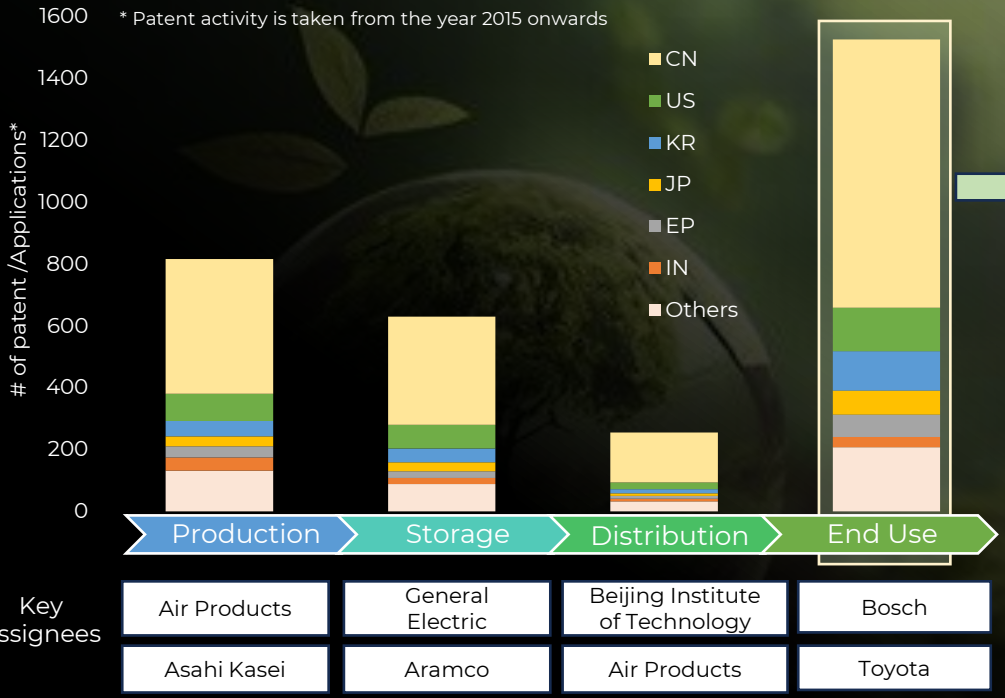
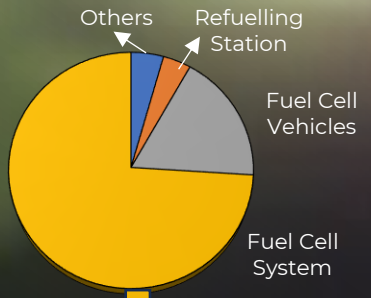
How AI can benefit the Hydrogen Ecosystem





AI in Fuel Cell Systems

- Diagnosis and Monitoring
- Stack Assembly analysis
- Performance optimization
- Degradation and aging
- Energy Management, etc.

- AI use cases are concentrated in the End-Use layer of the hydrogen value chain, particularly in fuel-cell systems, as their complex, dynamic operation requires intelligent, autonomous control to scale reliably.
- Bosch and Toyota are using AI and digital-twin technologies to fuel-cell systems to enable predictive maintenance, improve performance stability, and support reliable scaling in real-world deployment.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Industry News

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Fuel Cell Alliance

Toyota Motor Corporation aims to join Daimler Truck and Volvo Group as equal shareholder in the fuel cell joint venture Cellcentric

Daimler Truck, the Volvo Group, Toyota Motor Corporation have signed a non-binding Memorandum of Understanding to strengthen collaboration on fuel cell technology for heavy-duty applications. Under the agreement, Toyota plans to join Cellcentric as an equal shareholder alongside Daimler Truck and Volvo, contributing its long-standing expertise in fuel cell development and manufacturing. The collaboration aims to further establish cellcentric as a leading developer, producer and supplier of fuel cell systems for heavy-duty trucks, off-road vehicles and related applications. By combining the partners' complementary strengths, the initiative seeks to scale fuel cell technology and support hydrogen's role in decarbonising transport. cellcentric will continue operating as an independent entity, serving a broad range of customers while benefiting from the combined scale and expertise of all three partners.

Source: Toyota

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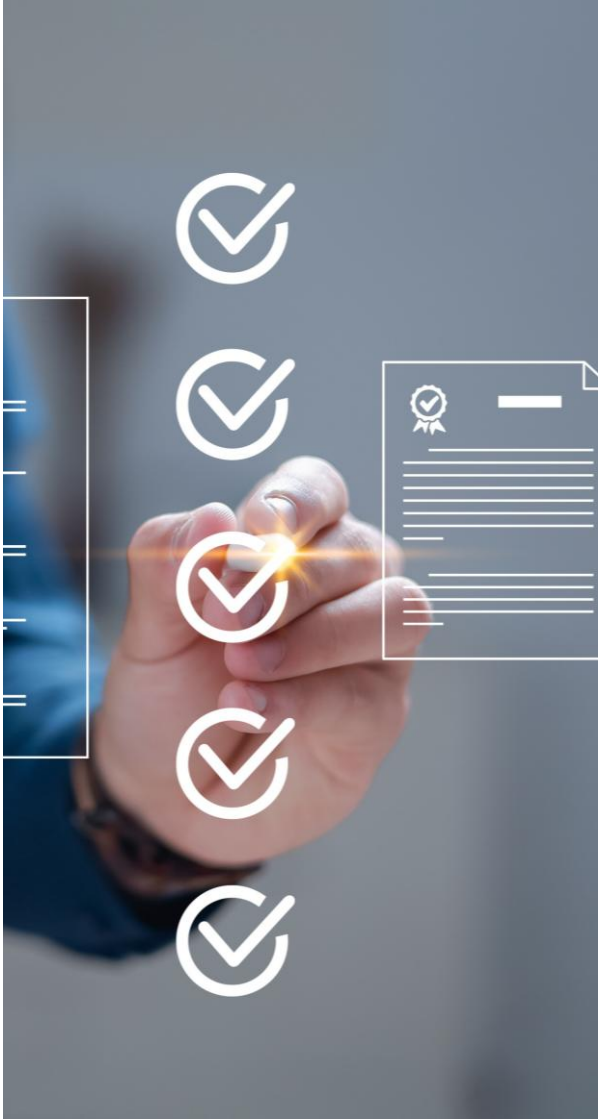
Industry News

RFNBO Certification

Italgas obtains ISCC RFNBO certification for green hydrogen produced at the Hyround plant in Sestu (Cagliari)

Italgas has secured ISCC RFNBO (Renewable Fuel(s) of Non-Biological Origin) certification for its Hyround green hydrogen plant in Sestu, Italy's first hydrogen facility directly connected to a city gas distribution network. The certification confirms that hydrogen production meets strict European standards for sustainability, renewable energy use, and full traceability under the EU Renewable Energy Directive (RED III). The plant uses Power-to-Gas technology, producing hydrogen via water electrolysis powered by a dedicated photovoltaic system, and currently generates about 21 tonnes of hydrogen per year, with plans to reach 70 tonnes by 2028. The certified hydrogen is intended for multiple uses, including public transport buses, blending into the local gas network, and supplying industrial users, demonstrating the role of gas infrastructure in enabling scalable green hydrogen integration and supporting Italy's energy transition.

Source: Italgas



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Industry News

Liquid Hydrogen Hub

KBR to set global benchmarks for liquid hydrogen engineering on EcoLog's Amsterdam terminal

KBR has been selected to deliver FEED for the EcoLog Terminal in the Port of Amsterdam, the world's first commercial-scale facility for importing liquid hydrogen (LH_2) and exporting liquid CO_2 (LCO_2). Targeted for operation by 2030, the terminal will support Europe's decarbonisation by supplying hydrogen and managing CO_2 for industrial and transport sectors, with initial capacities of 200,000 tonnes of LH_2 and 1.8 million tonnes of LCO_2 per year. KBR's scope includes defining the terminal's engineering, cryogenic systems, and safety standards, drawing on its expertise in liquid hydrogen infrastructure. The project also integrates next-generation LH_2 carriers, multimodal transport links, and reuse of cold energy from hydrogen regasification to liquefy CO_2, setting new benchmarks for hydrogen and carbon infrastructure.

Source: KBR

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Industry News

Hydrogen Refueling

Asahi Kasei begins installation of containerized alkaline-water electrolyzer at Finland's first commercial hydrogen refueling station

Asahi Kasei has started installing a containerized 1 MW-class Aqualyzer™-C3 alkaline water electrolyzer at Finland's first commercial hydrogen refueling station in Jyväskylä. Supplied to the Central Finland Mobility Foundation (Cefmof), the system will produce about 400 kg of hydrogen per day, enough to refuel around three fuel cell vehicles per hour, and will support hydrogen-powered transport in cold-climate conditions. The electrolyzer will be operated by Cefmof Hydrogen and is scheduled to begin operations in summer 2026, marking one of Finland's first installations of a containerized alkaline electrolyzer at this scale. Leveraging over 50 years of electrolysis expertise, Asahi Kasei is using the project to demonstrate the reliability and scalability of its hydrogen production technology and support the expansion of Europe's hydrogen ecosystem.

Source: Asahi Kasei

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Industry News

Fuel-Cell Mobility

Bosch is extending its portfolio with new fuel-cell solutions for buses

Bosch has unveiled its new fuel-cell power module FCPM C100 at the Mobility Move trade fair in Berlin, expanding its portfolio of fuel-cell systems for climate-friendly public transport. Designed specifically for city buses, the compact 100-kilowatt module features a flat, roof-mountable design well suited to European urban vehicles and enables fully electric, CO_2-free operation when powered by renewable hydrogen. The C100 complements Bosch's broader fuel-cell range, which spans 100 to 300 kilowatts and includes variants for intercity buses, coaches, and heavy trucks. Alongside vehicle-integrated fuel cells, Bosch highlighted its solutions across the entire hydrogen value chain, from hydrogen production with its Hybrion PEM electrolyzer to hydrogen engines, underscoring its long-term commitment to supporting zero-emission mobility and the development of a hydrogen economy.

Source: Bosch

The editor's shortlist

Patents of the month

Green **Green patent indicator** powered by Octimine Dennemeyer IP Group

Patents of the month

Published in Mar 2025

Shortlisted and summarized by our analyst

- US2026073313A1 - Mission management system for a heavy-duty vehicle and a computer-implemented method
  Assignee: Volvo Truck Corp (Sweden)
- US2026088618A1 - Hydrogen energy storage and energy aggregation systems utilizing machine learning for virtual power plants
  Assignee: Oreqa Tech Inc (US)
- US2026063247A1 - Method for delivering liquid hydrogen Green
  Assignee: Air Liquide SA (France)
- US2026088320A1 - System for a dual input fuel cell Green
  Assignee: Caterpillar Inc (US)
- US2026066316A1 – Method for controlling anode purge valve of fuel cell, device, medium, and product Green
  Assignee: Tongji Univ (China)
- EP4713616A1 - A hydrogen refueling system Green
  Assignee: Cavendish Hydrogen AS (Denmark)
- DE102025134825A1 - Fuel cell contamination detection Green
  Assignee: Ford Global Technologies LLC (US)
- IN202441066908A - Low temperature proton exchange membrane fuel cell for high-altitude operating commercial vehicle applications
  Assignee: Ashok Leyland Limited (India)
- CN121683614A - Proton exchange membrane electrolytic tank flow field design optimization method based on machine learning assistance
  Assignee: Central South University (China)
- CN121756983A - Digital twin-based solid-state hydrogen storage thermal management system for hydrogen fuel cell vehicle
  Assignee: Lanzhou Jiaotong University (China)

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Latest patents

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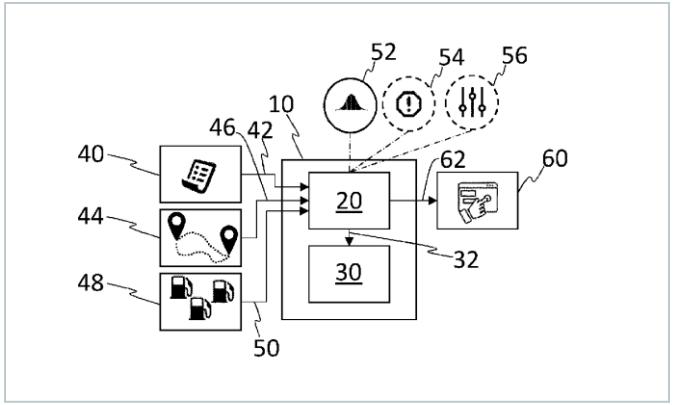
US2026073313A1

Mission management system for a heavy-duty vehicle and a computer-implemented method



This invention introduces a mission-management system for heavy-duty vehicles operating in environments with limited hydrogen refueling or battery-charging infrastructure. The system analyzes a transport mission by identifying possible routes and available energy-supply stations with unbooked time slots, then evaluates the probability of missing those slots due to delays or congestion. It also considers a criticality measure such as remaining energy level, queue times, costs, driving limits, and distance, to balance risk and operational efficiency. Based on these factors, the system selects and can automatically book an optimal route and energy re-supply plan, while dynamically updating the plan during the mission as conditions change, improving reliability and reducing operational delays.

Company name	Volvo Truck Corp (Sweden)
Inventors	Desai Parthav, Suman Saurabh
Priority date	06-Sep-2024
Publication date	12-Mar-2026

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US2026088618A1

Hydrogen energy storage and energy aggregation systems utilizing machine learning for virtual power plants

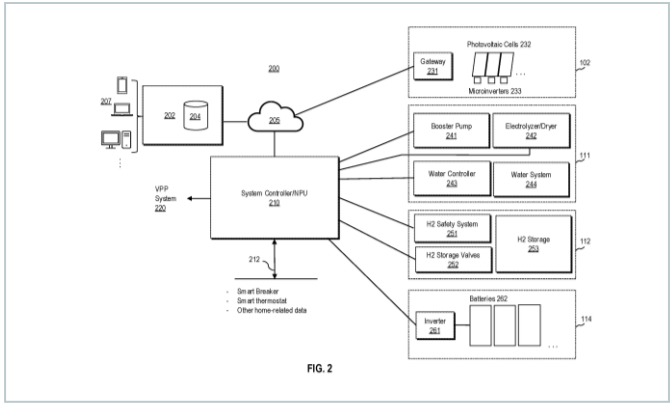

FIG. 2

Company name	Oreqa Tech Inc (US)
Inventors	Gregoire-mazzocco Herve-david, Widmer Sean G
Priority date	26-Nov-2025
Publication date	26-Mar-2026

This invention presents an integrated energy-control system that combines solar power generation, hydrogen-based energy storage, batteries, and a virtual power plant (VPP) interface to manage renewable energy under both grid-connected and off-grid conditions. The system uses components such as electrolyzers, hydrogen storage units, fuel cells, inverters, and smart sensors, coordinated by machine-learning agents trained with reinforcement learning. These agents analyze real-time data from loads and grid conditions to determine when to store excess solar energy as hydrogen, generate electricity, manage or shed loads, or interact with energy markets through the VPP. Built on a scalable “fractal grid” architecture, the same control logic can be applied from individual buildings to larger grid segments, improving efficiency, flexibility, and resilience in renewable energy management.

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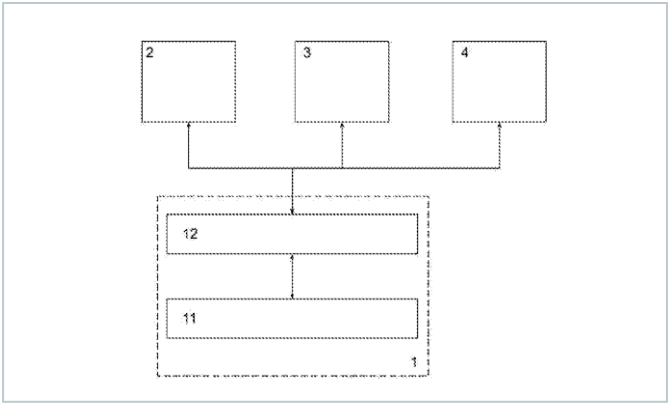

US2026063247A1 Green

Method for delivering liquid hydrogen

Company name	Air Liquide SA (France)
Inventors	Dudret Stephane, Benichou Pierre
Priority date	29-Aug-2024
Publication date	05-Mar-2026

This patent presents a method for delivering liquid hydrogen that improves efficiency and safety by configuring the target storage tank to a preset thermodynamic state before transfer. Instead of adapting only the intermediate tank, the approach determines system state data, predicts performance using models, and prepares the target tank to enable optimized hydrogen delivery. The method dynamically updates system states and configuration settings during delivery using real-time sensor data and considers factors such as withdrawal rates, tank ageing, maintenance, and logistics. By proactively preparing the target tank and adapting to changing conditions, the approach reduces hydrogen losses, stabilizes pressure and temperature, and enhances overall delivery efficiency.

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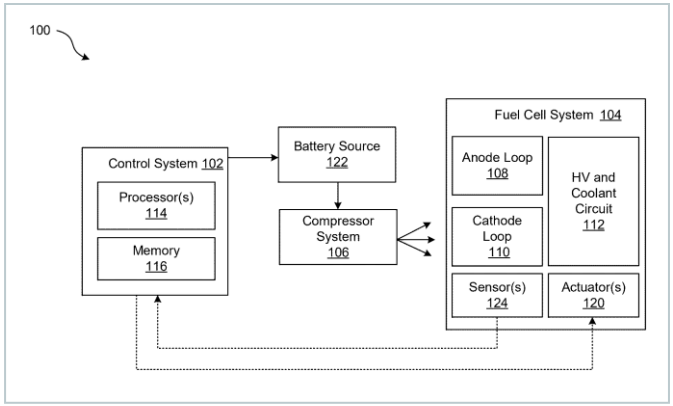
US2026088320A1 Green

System for a dual input fuel cell



Company name	Caterpillar Inc (US)
Inventors	Mahajan Ravinder Das, Pierpont David Andrew
Priority date	23-Sep-2024
Publication date	26-Mar-2026

Summarized by Dennemeyer

This patent describes a dual-input fuel cell system that increases flexibility by allowing operation with either methanol, hydrogen, or a combination of both fuels. The system includes separate storage tanks, flow-control valves, and a processing circuit that selects the appropriate fuel based on availability or user preference, with methanol converted into hydrogen via a reformer before entering a high-temperature PEM fuel cell. To improve efficiency, excess hydrogen and oxygen are routed through a catalytic converter to recover energy and raise exhaust temperature, which is then used by a turbocharger and heat-recovery components. By integrating intelligent fuel switching, exhaust energy recovery, and dual-fuel capability, the invention enhances system efficiency, power density, and operational flexibility for vehicle and stationary fuel cell applications.

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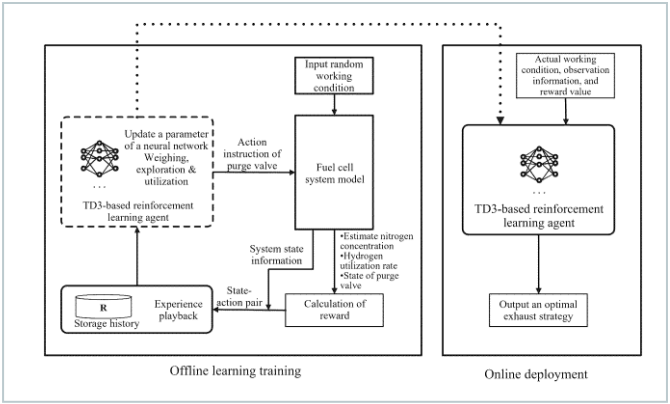

US2026066316A1 Green

Method for controlling anode purge valve of fuel cell, device, medium, and product

Company name	Tongji Univ (China)
Inventors	Dai Haifeng, Liu Zhaoming, Yuan Hao, Miao Wenxiong, Wei Xuezhe
Priority date	30-Aug-2024
Publication date	05-Mar-2026

Summarized by Dennemeyer

This patent introduces an intelligent control method for managing the anode hydrogen discharge valve in proton exchange membrane fuel cell vehicles with dead-end anodes, where nitrogen buildup can reduce performance and hydrogen efficiency. Instead of fixed exhaust intervals, the invention uses a reinforcement learning–based neural network model, specifically the Twin Delayed Deep Deterministic Policy Gradient (TD3) algorithm, to adapt valve operation in real time. The model evaluates operating parameters such as nitrogen concentration, hydrogen utilization, and load conditions to determine optimal exhaust actions. Trained offline using simulated data and applied online for real-time control, the approach improves system stability, increases hydrogen utilization, and enhances overall fuel cell efficiency.

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EP4713616A1 Green

A hydrogen refueling system

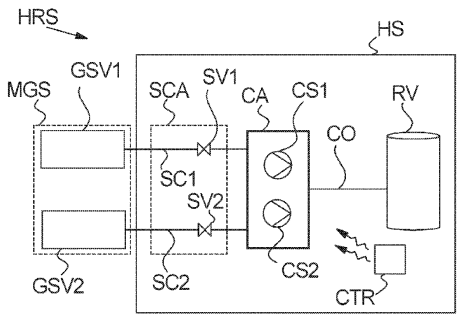

Fig. 1

Company name	Cavendish Hydrogen AS (Denmark)
Inventors	Dorner Sascha, Stefan Michael
Priority date	16-May-2023
Publication date	25-Mar-2026

This patent introduces an advanced hydrogen refueling system designed to increase filling speed while preventing damaging temperature drops in supply vessels. The system uses multiple mobile gas supply vessels connected through separate conduits and individually controlled valves to dedicated compression stages that feed a common outlet for the receiving vessel. By allowing simultaneous gas flows from two or more supply vessels and independently controlling flow rates based on real-time parameters such as pressure, temperature, and state of charge, the system optimizes emptying without causing critical cooling. Flexible compression configurations, cascade bypassing, and integrated heat exchangers further enhance efficiency and safety, enabling faster, continuous, and more reliable hydrogen refueling operations.

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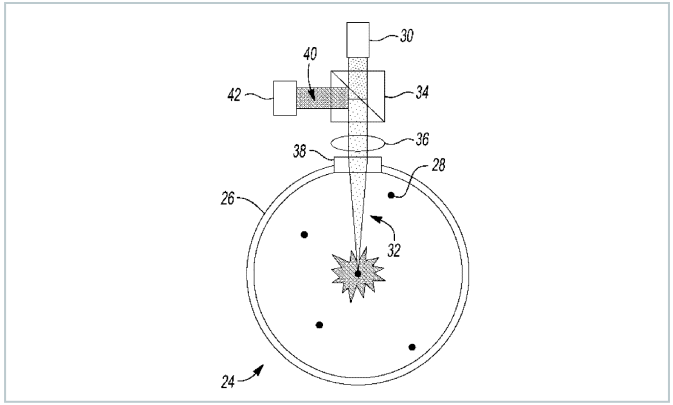
DE102025134825A1 Green

Fuel cell contamination detection



Company name	Ford Global Technologies LLC (US)
Inventors	Kempema Nathan, Wilkosz Daniel
Priority date	03-Sep-2024
Publication date	05-Mar-2026

This invention introduces a fuel cell system with a non-invasive optical method for real-time detection of contaminant particles that can degrade proton exchange membrane fuel cell performance. A laser-based optical setup directs a focused light beam into the hydrogen gas inlet, where metal-oxide particles interact with the light and emit detectable signals analyzed using spectroscopic techniques such as light scattering or laser-induced emission. By identifying the presence, size, and composition of contaminants without system disassembly, the system enables early detection of corrosion-related degradation. Robust optical interfaces integrated into the gas line allow continuous monitoring under operating temperatures and pressures, improving system reliability and durability in automotive fuel cell applications.

Summarized by Dennemeyer

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IN202441066908A

Low temperature proton exchange membrane fuel cell for high-altitude operating commercial vehicle applications

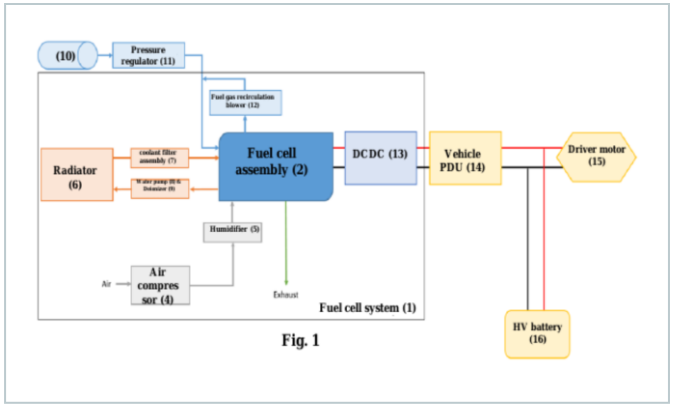

Fig. 1

Company name	Ashok Leyland Limited (India)
Inventors	Dr Karthikeyan S, Hari Baskar P, Dr Gopi Sankar M
Priority date	04-Sep-2024
Publication date	06-Mar-2026

This invention describes a low-temperature proton exchange membrane (PEM) fuel cell system designed specifically for commercial vehicles operating at high altitudes. To address challenges such as reduced oxygen availability, membrane drying, cooling inefficiencies, noise, and safe exhaust handling, the system integrates a dual-stage electric air compressor, intercooler and humidifier, efficient coolant filtration and de-ionization, and advanced thermal management components. The design ensures proper air humidification, stable cooling, low coolant conductivity, reduced noise, and safe exhaust emissions across varying altitudes. By combining optimized air supply, coolant conditioning, noise reduction, and adaptive control methods, the invention improves reliability, efficiency, durability, and safety of PEM fuel cell systems for high-altitude vehicle applications.

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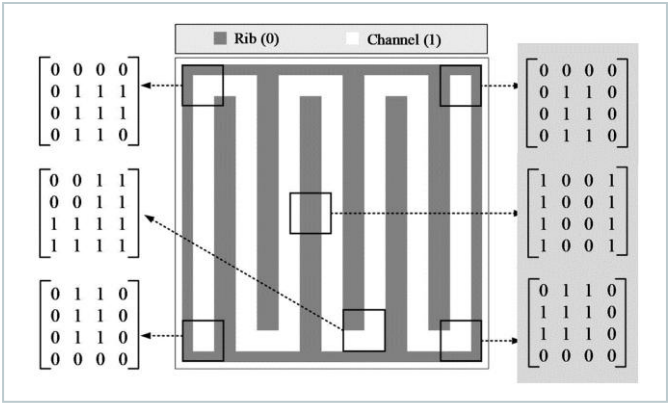

CN121683614A

Proton exchange membrane electrolytic tank flow field design optimization method based on machine learning assistance

Company name	Central South University (China)
Inventors	Furusawa Koichiro, Murata Naotaka, Takahashi Kazuyuki, Uenodai Asao
Priority date	15-Dec-2025
Publication date	17-Mar-2026

This patent introduces a machine learning–enabled method to optimize flow field designs in proton exchange membrane (PEM) electrolyzers, addressing uneven mass transfer, poor gas removal, and non-uniform temperature control. The approach generates a large library of candidate flow fields using a depth-first search algorithm and screens them through image-based representations for favorable transport characteristics. A multi-layer perceptron (MLP) model then predicts key performance metrics such as pressure drop, oxygen flow velocity, and temperature uniformity from geometric features. By rapidly identifying high-performance flow fields, the method improves hydrogen production efficiency while significantly reducing design time and computational effort compared to conventional optimization methods.

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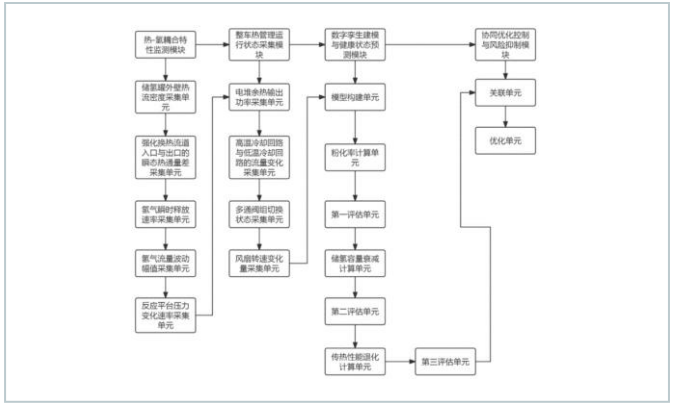
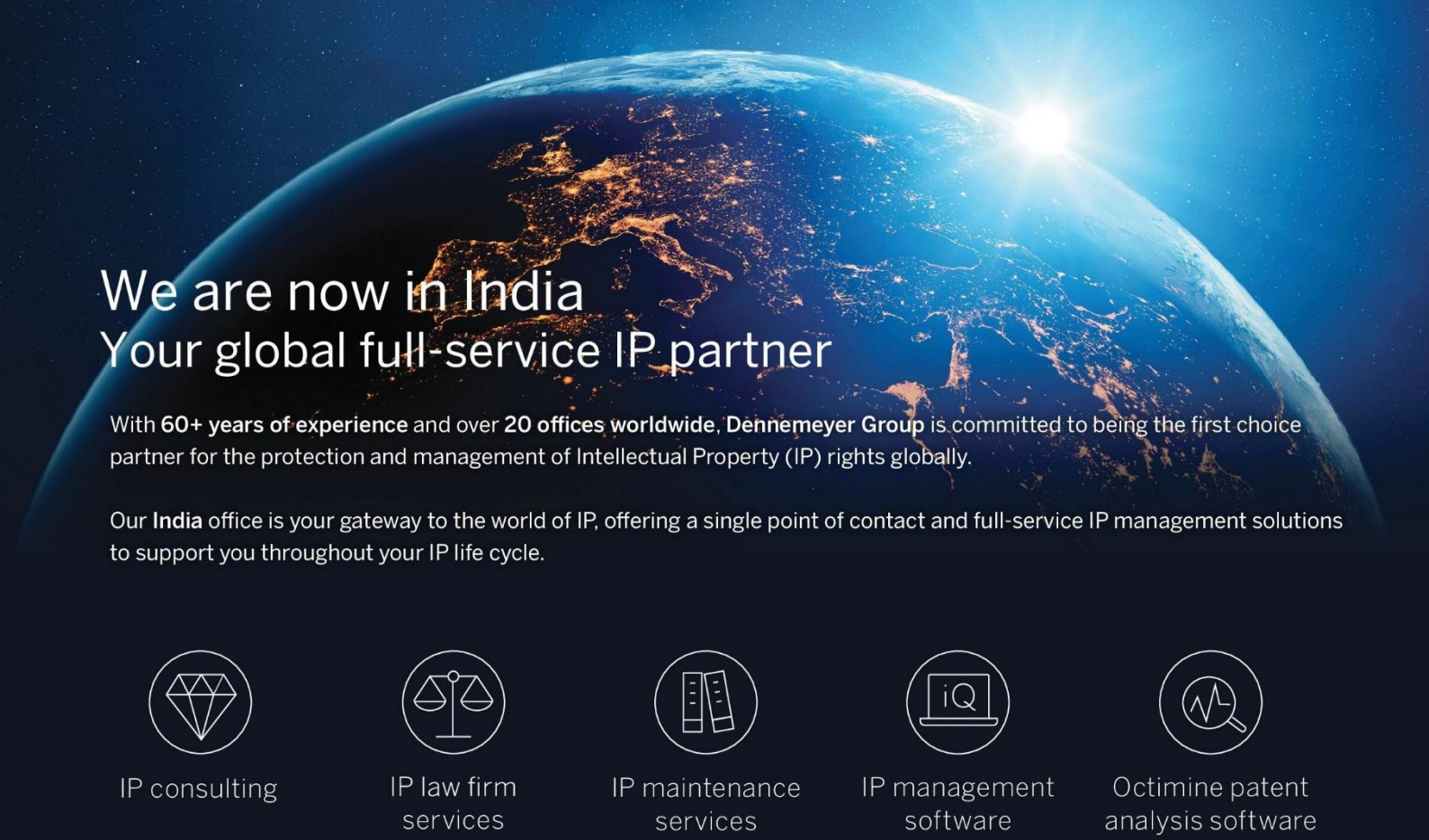
CN121756983A

Digital twin-based solid-state hydrogen storage thermal management system for hydrogen fuel cell vehicle



This patent introduces a digital twin–based thermal management system for solid-state hydrogen storage in hydrogen fuel cell vehicles to improve efficiency, safety, and durability. It gathers multi-source real-time data on heat transfer, hydrogen release, and vehicle thermal states, and applies a neural-network-based digital twin model to predict internal temperature distribution, hydrogen concentration, and material phase changes within the storage tank. Using these predictions, it evaluates health indicators such as material degradation, hydrogen capacity loss, and heat-transfer performance, combining them into a health risk coefficient. This metric drives coordinated control of waste heat utilization, hydrogen release, and cooling components to reduce energy consumption, stabilize hydrogen supply, prevent overheating, and extend the service life of the hydrogen storage tank.

Company name	Lanzhou Jiaotong University (China)
Inventors	Ma Lu, Song Kewei, Yan Ruqi, Chai Baodui, Chen Weilong
Priority date	21-Jan-2026
Publication date	31-Mar-2026



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