

Special Edition – June 2025

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 focuses on Proton Exchange Membrane (PEM) electrolyzers used in clean hydrogen production and explores how the cost of electrolyser stack can be reduced.

Special Edition

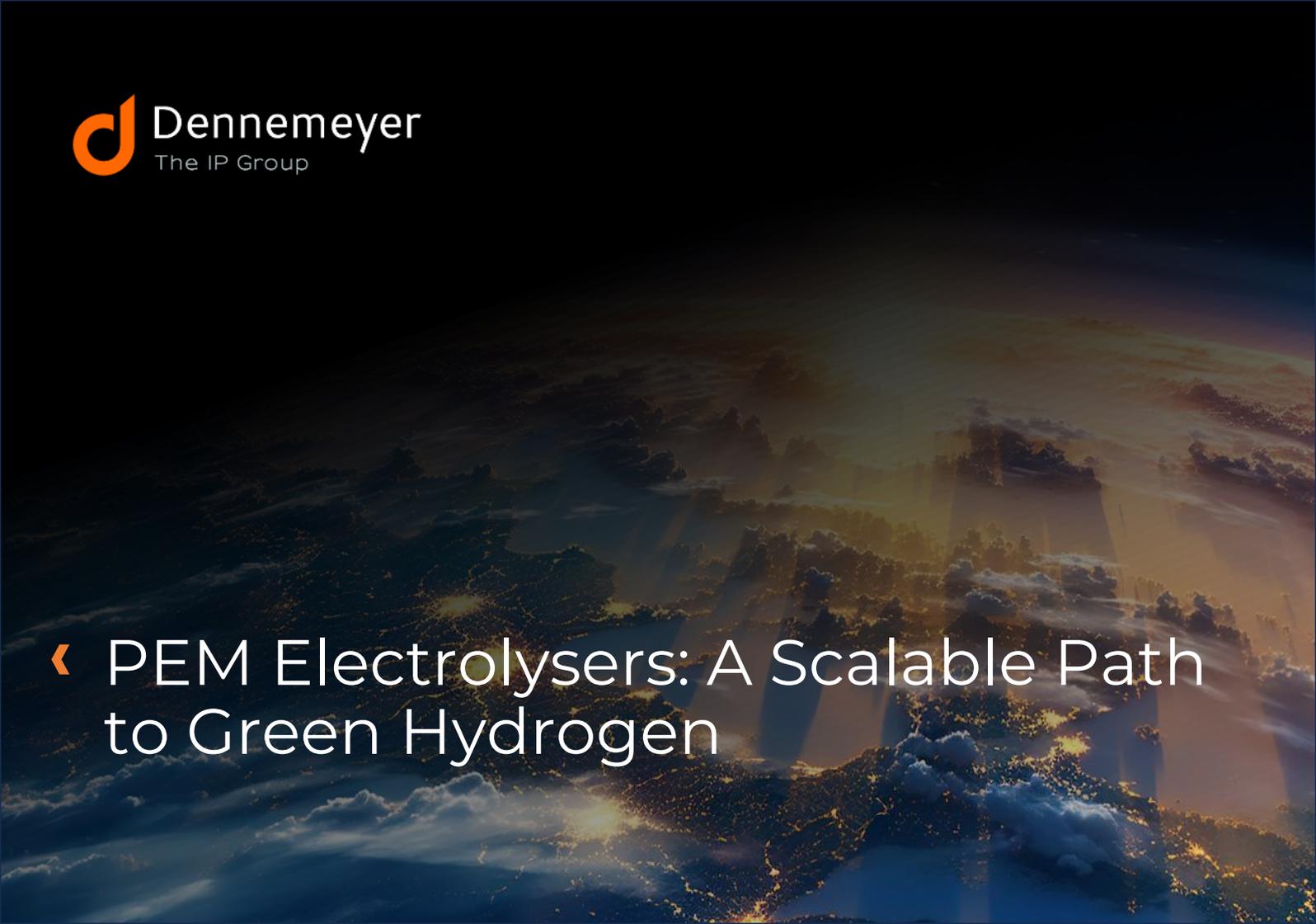
This special edition report highlights the vital role of Proton Exchange Membrane (PEM) electrolyzers in clean hydrogen production. It explores key stack components and cost-reduction opportunities through alternative materials and manufacturing methods. It further analyzes global patent trends for each stack component and examines how material innovations are driving down costs. The report also looks into India's contribution to PEM-related patent activity.

This month's report includes the following content:

- [PEM Electrolyzers: A Scalable Path to Green Hydrogen](#)
 - [PEM Electrolyser: Why to Choose and What are the Barriers in Scaling](#)
 - [Major Components of a PEM Electrolyser Stack, Cost and Material Used](#)
 - [Trend in Patent filing of PEM Electrolyser Stack Vis-a-Vis Reduction in Electrolyser Stack CAPEX Cost](#)
 - [Indian Patenting Trends on PEM Electrolyser Stack](#)
- [Industry news](#)
- [Patents of the month](#)

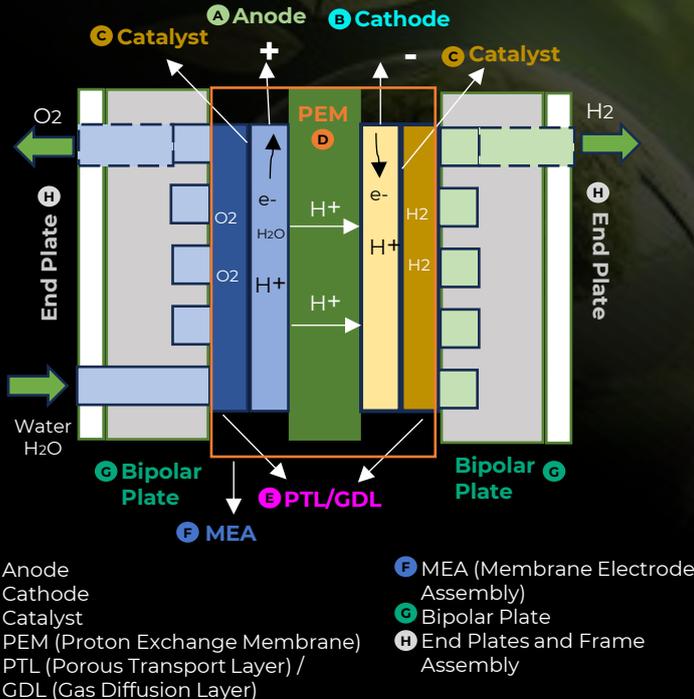
Key Insights this month

- ❑ Cost reduction in PEM electrolyzers is achievable through advancements in material engineering such as reducing reliance on expensive catalysts like Iridium and Platinum alongside improved system design, process innovation, and economies of scale in manufacturing. Combining these strategies can significantly lower production costs and enhance commercial viability of PEM Electrolyzers.
- ❑ India's current focus in the PEM electrolyser domain is primarily on system integration, while a significant proportion of patents in core technologies are held by international entities. To enhance self-reliance and long-term competitiveness, increased investment in foundational R&D particularly in stack components and stack design is crucial.
- ❑ Advancements in core stack components such as reduced Iridium loading for anodes and alternative materials for catalysts and membranes are key drivers of future cost reductions in PEM electrolyzers. However, these innovations typically require 3–4 years for validation, scale-up, and integration. Post-2020 policy shifts are further accelerating development by providing a stronger foundation for technology deployment and investment.
- ❑ Major industry players are forming strategic partnerships such as Samsung E&A with Nel, and BrightHy Solutions with Sungrow Hydrogen, to accelerate green hydrogen deployment. These collaborations combine cutting-edge electrolyser technology with engineering expertise, driving down costs and improving system efficiency through optimized design and integration.
- ❑ Recent published patent applications focus on improving membrane durability by modifying materials such as using nitrogen-containing heterocyclic polymers and structures, like specially designed polyolefin-based porous supports or novel membrane cathode assemblies. They also target operational efficiency improvements in balance of plant (BOP) components.



◀ PEM Electrolysers: A Scalable Path to Green Hydrogen

Electrolysers are central to clean hydrogen production, with Proton Exchange Membrane (PEM) technology standing out as one of the most efficient option compared to alternatives like Alkaline and Solid Oxide Electrolysers.



Why Choose PEM Electrolysis?

- Higher Current Density (0.6–2 A/cm²)
- PEM electrolyzers can operate at high pressures (up to 200 bar) and low temperatures (50–80°C), reducing downstream compression needs and improving overall efficiency.
- They can produce hydrogen with a purity of 99.97 % without the need of additional purification equipment.
- Fast proton transport in Nafion membranes makes PEM electrolyzers well-suited for direct use with variable renewable energy sources.

Barriers to Scaling as of today

- **Cost:** High capital cost due to use of precious metal catalysts (e.g., Platinum, Iridium)
- **Material Constraints:** Limited availability of Iridium and Platinum affects scalability
- **Durability:** Shorter lifespan compared to Alkaline electrolyzers

Electrolyser stack represents often 40-60% of total CAPEX cost of manufacturing Hydrogen.

Stack Components	% of Electrolyser Stack cost	Materials Currently in Use	Alternative Materials (Future Potential)
<ul style="list-style-type: none"> A Anode B Cathode C Catalyst 	20 to 30%	<ul style="list-style-type: none"> A Iridium oxide (IrO₂), Ruthenium oxide (RuO₂) B Platinum (Pt) black or Pt layers on a carbon core C Precious metals (Pt, Ti) 	<ul style="list-style-type: none"> A Low-loading of Iridium (Ir) B Molybdenum-based materials (MoS₂, MoP), Ni-based compounds (with surface modification) C TiC, Sb₂O₅, NbC
D PEM (Proton Exchange Membrane)	13 to 23%	D Perfluorosulfonic acid (PFSA) membrane such as Nafion	D Ultra-thin, durable membranes Polybenzimidazole (PBI), Sulfonated Polyether Ether Ketone Microporous Polymer Meshes)
E PTL (Porous Transport Layer) / GDL (Gas Diffusion Layer)	17 to 25%	E Carbon paper on the cathode side and sintered Titanium foam or felt on the anode side	E Nickel foam, Carbon-metal composites for cathode side Titanium-coated stainless steel, Metal meshes for anode side
G Bipolar Plate	12 to 21%	G Platinum group metals or Titanium cores coated with Platinum group metals	G Non-precious metals such as combination of titanium, cobalt, and nickel
H End Plates and Frame Assembly	3 to 13%	H End plates - Stainless Steel, Aluminum; Assembly - Polymer Composites, Epoxy Resins, or Reinforced Plastics	H End plates - Coated stainless steel or aluminum, High-performance polymers (PEEK, PPS); Assembly - Polytetrafluoroethylene (PTFE) or fluoropolymer linings

- 60-70% of the electrolyser stack cost driven by expensive raw materials and manufacturing of stack components; significant cost reductions up to 50% are expected by 2030 through alternate material and process innovation.
- Iridium (Ir) is the bottleneck in scale-up due to its rarity (7.5 tons of Ir mined per year, compared to ~200 tons for Platinum). Notable progress has been made in Iridium usage (reducing loadings from >1 mgIr/cm² to below 0.5 mgIr/cm² for Anode).

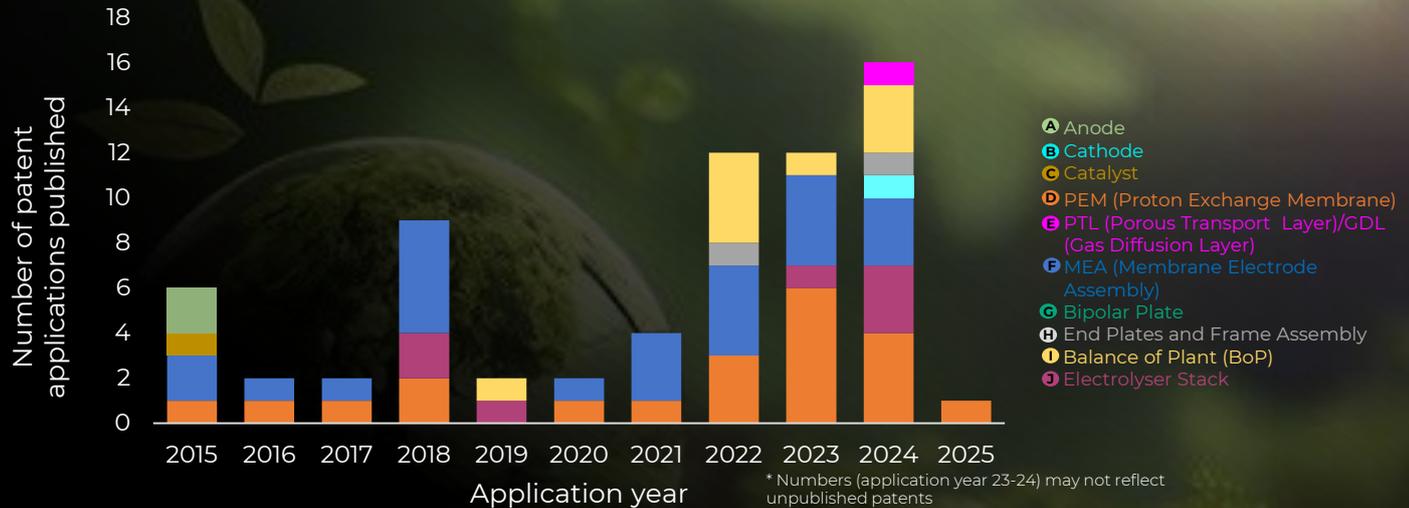
Trend in Patent filing of PEM Electrolyser Stack Vis-a-Vis Reduction in Electrolyser Stack CAPEX Cost



As illustrated in the graph, advancements in key stack components such as low loading of Iridium for anode, and alternate materials for catalyst and membranes are, accelerating. However, these innovations typically take 3 to 4 years to translate into cost reductions, reflecting the time needed for validation, scale-up, and integration into production.

- In 2018, Iridium prices increased significantly due to limited global supply, which led to increase in the price of electrolyser stack.
- Before 2020, global green hydrogen policies were fragmented or lacked strength. After 2020, stronger frameworks like the EU Green Deal and U.S. IRA emerged, driving progress and accelerating electrolyser development.

Indian Patenting Trends on PEM Electrolyser Stack



- **Foreign Filing >> Domestic Priority Filing:** Around 60% of PEM electrolyser-related patents in India are filed by foreign entities, primarily from the US and EU, indicating strong external interest and technological lead.
- **Early-Stage Domestic R&D:** Indian academic institutions (IITs, NITs and Research Institutes) are beginning to explore PEM electrolyser materials mainly membranes, signaling early-stage research activity with significant room for growth.
- **Focus on Integration and Collaboration:** In case of India the focus area in the latest patents is also on (Stack deployment and Balance of Plant (BoP)) indicates that Indian companies appear to be importing electrolyser stacks and focusing on system integration.



◀ Industry News

Low-Cost Hydrogen Solution

SAMSUNG E&A launch new Hydrogen solution CompassH2

Samsung E&A, a total solutions provider for the global energy industry, in collaboration with Nel (the worldwide leader in hydrogen electrolyser technology), has launched CompassH2, a next-generation green hydrogen production plant solution, officially debuting at the World Hydrogen Summit 2025 in Rotterdam. Combining Nel's leading electrolyser technology with Samsung E&A's engineering expertise, CompassH2 aims to deliver the lowest Levelized Cost of Hydrogen (LCOH) through optimized system design, high efficiency, and reduced CAPEX. The solution includes system-level performance guarantees, end-to-end lifecycle support, and full integration across the hydrogen value chain, from feasibility to EPC execution. With a scalable base capacity of 100 MW, it ensures high purity hydrogen and compact, efficient plant layout.



Electrolyser Market Alliance

BrightHy Solutions forge strategic partnership with Sungrow Hydrogen to deliver cutting-Edge Hydrogen Solutions in Iberia

BrightHy Solutions, a leading provider of hydrogen solutions, has entered a strategic agency and partnership agreement with Sungrow Hydrogen to accelerate the deployment of advanced green hydrogen production equipment in the Iberian market. Building on existing collaboration, BrightHy will act as Sungrow's agent, offering tailored solutions backed by its engineering expertise and strong local presence. Sungrow Hydrogen, a global leader in water electrolysis technology with over 550 patents and world-class R&D platforms, brings cutting-edge Alkaline (ALK) and PEM (Polymer Exchange Membrane) electrolyser systems. This partnership aims to integrate flexible, intelligent, and safe hydrogen solutions for industrial and energy sectors, marking a significant step toward advancing sustainable energy in the region.



JCBs EU Type-Approval

JCB secures full EU type-approval for pioneering hydrogen engine

JCB has achieved a major milestone by becoming the first construction equipment company to receive full EU type-approval for its hydrogen combustion engine used in non-road mobile machinery. Certified under EU Regulation 2016/1628 and compliant with Stage V emissions norms, the approval allows the engine to be sold and operated across all 27 EU member states and other regions recognizing EU type-approvals. This follows earlier provisional approvals in nine European countries and GB type-approval. The certification confirms the viability of hydrogen as a zero-CO₂ fuel for internal combustion engines. JCB has invested £100 million in the project, with 150 engineers developing over 130 hydrogen engines, now powering equipment like backhoe loaders and telehandlers, with advanced real-world testing underway.



Hydrogen Flight Testing

AMSL Aero unveils breakthrough results of hydrogen aviation testing at Bankstown airport

AMSL Aero, Australia's zero-emission aircraft designer and manufacturer, has successfully completed its first year of hydrogen fuel cell testing at Bankstown Airport, marking a major step toward emission-free flight testing within 12 months. Using over 200 kg of hydrogen, the company operated a 100kW fuel cell test bench, the only known one of its kind in Australia which served as a fully functional mock-up of the Vertiiia eVTOL (electric Vertical Take-Off and Landing) aircraft's hydrogen powertrain. The tests not only validated Vertiiia's hydrogen system, capable of 1,000 km zero-emission range, but also supplied 30kW of electricity to the airport grid over three weeks, saving 1.8 MWh of energy. AMSL's work has helped Bankstown Airport become the first in Australia to use hydrogen as aviation fuel, advancing national goals for net-zero aviation. The test bench is now also in use at Wellington Aerodrome for recharging Vertiiia between flights.

Source: [AMSL Aero](#)



Hydrogen Supply Chain

Honeywell Technology is selected for first commercial hydrogen supply chain via MCH

Honeywell and Japan's leading energy company, ENEOS, have begun basic engineering to develop the first commercial-scale hydrogen supply chain. This will use Honeywell UOP's (Universal Oil Products) methylcyclohexane (MCH) dehydrogenation process, forming a key part of Honeywell's Liquid Organic Hydrogen Carrier (LOHC) solution. The project spans the full hydrogen value chain production, storage, transport, distribution, and material recovery with MCH enabling safe, long-distance hydrogen transport. Hydrogen gas is converted into MCH via Honeywell's Toluene Hydrogenation process, transported by ship or tanker, and then reconverted to hydrogen through MCH dehydrogenation at the destination. The byproduct, Toluene, is recycled for reuse. This collaboration supports ENEOS's goal to deploy the MCH process within its Japanese refineries and build on ongoing efforts to advance hydrogen infrastructure and commercial viability in the region.

Source: [Honeywell](#)



The editor's shortlist

◀ Patents of the month



Patents of the month

Published in May 2025

Shortlisted and summarized by our analyst

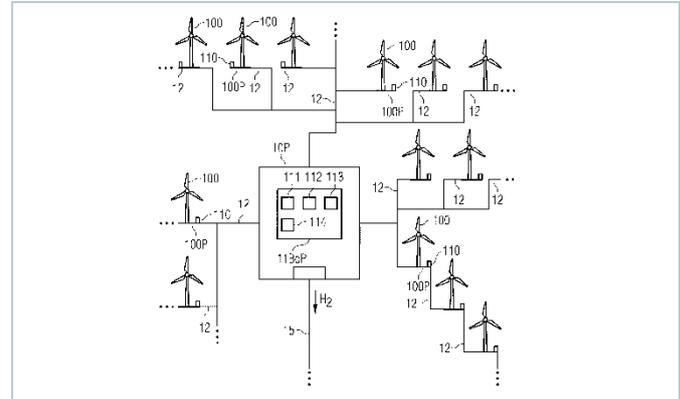
- [US2025163592A1](#) - Wind-powered electrolysis arrangement
Assignee: Siemens Gamesa Renewable Energy AS (Spain)
- [US2025167272A1](#) - Systems and methods for pressurizing hydrogen used in proton exchange membrane fuel cells
Assignee: Caterpillar Inc (USA)
- [US2025146154A1](#) - Process to produce hydrogen and oxygen from underground systems
Assignee: DeepH2 Inc (USA)
- [US12292749B2](#) - Multiple output header
Assignee: Ohmium International Inc (USA)
- [JP2025078675A](#) - Ion exchange membrane, polyolefin-based porous membrane, membrane electrode assembly, water electrolysis device, and method for producing polyolefin-based porous membrane
Assignee: Tokuyama Corp (Japan)
- [EP4559065A1](#) - Method and plant for producing hydrogen
Assignee: Linde GMBH (Germany)
- [EP4558664A1](#) - Energy efficient Lithium Chloride electrolytic process and electrolyzer plant
Assignee: Noram Electrolysis Systems Inc (Canada)
- [IN202517019610A](#) - Nitrogen-containing heterocyclic polymer, and polymer film and use thereofvehicle
Assignee: Wuhan Limo Technology Co Ltd (China)
- [DE102024101502B3](#) - Membrane electrode arrangement
Assignee: GM Global Technology Operations LLC (USA)
- [CN120020278A](#) - PEM (PEM) electrolytic tank testing system and method
Assignee: Tehi Hydrogen Energy Testing Baoding Co Ltd (China)



US2025163592A1

Green

Wind-powered electrolysis arrangement



The patent describes a novel offshore wind-powered hydrogen production system that improves the efficiency and scalability of green hydrogen generation. It does so by integrating distributed electrolyzers directly with wind turbines, each forming a Decentralized Offshore Hydrogen Plant (DOHP). In this design, electrolyzers are installed directly on individual wind turbine platforms, using power from their respective turbines, while essential support systems (Balance of Plant (BOP)) such as water purification, nitrogen supply, and hydrogen collection are centralized on a main platform. This approach significantly reduces power losses, lowers infrastructure costs, simplifies maintenance, and improves overall hydrogen production efficiency through optimized product exchange between turbines and the central BOP.

Company name Siemens Gamesa Renewable Energy AS (Spain)

Inventors Eggers Jan Rudolf,
Hellstern Henrik Christian Lund,
Von Der Heyde Michael

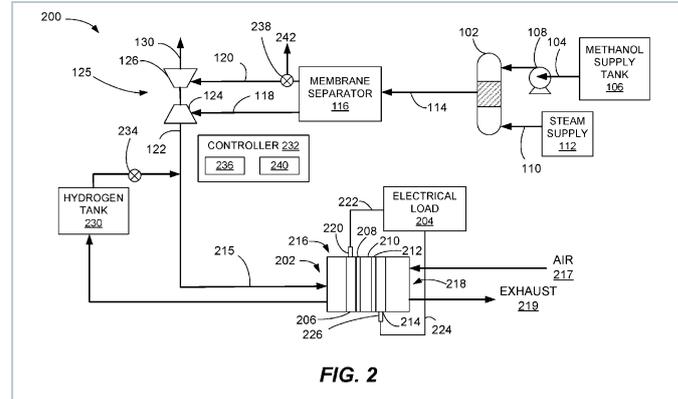
Priority date 16-Nov-2023

Publication date 22-May-2025



US2025167272A1  Green

Systems and methods for pressurizing hydrogen used in proton exchange membrane fuel cells



The patent introduces an efficient method for pressurizing hydrogen for use in Proton Exchange Membrane (PEM) fuel cells by leveraging waste energy from the hydrogen production process. Instead of relying on external energy sources or electrically powered pumps, it reuses leftover energy from the hydrogen-making process. It does this by using a turbocharger that captures pressure from unused gases to help compress the hydrogen. This approach overcomes the limitations of prior systems that relied solely on exhaust pressure, which could be insufficient under high load conditions. By utilizing otherwise wasted energy from the production process, the system enhances energy efficiency and reliability in hydrogen-powered fuel cells.

Company name Caterpillar Inc (USA)

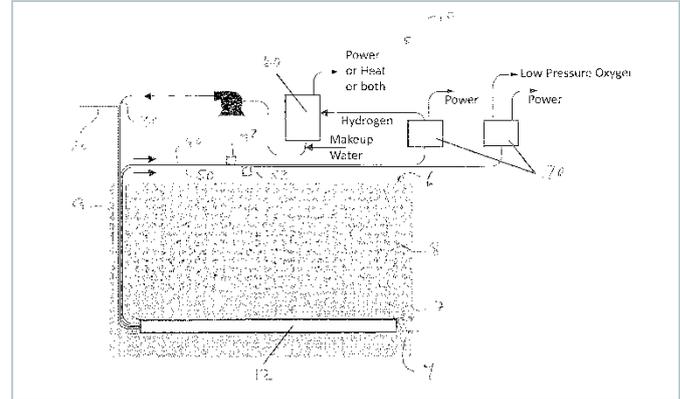
Inventors Hanks Benjamin William,
Boley William Christopher,
Ginter David M

Priority date 16-Nov-2023

Publication date 22-May-2025

US2025146154A1 

Process to produce hydrogen and oxygen from underground systems



This invention presents a novel underground hydrogen production system that utilizes geothermal heat and sub-surface pressure to enhance water electrolysis efficiency. Electrolysers are deployed deep within wells, where naturally high temperatures and pressures assist in generating and pressurizing hydrogen and oxygen without the need for extensive surface infrastructure. Water and electricity are supplied from the surface, and the produced gases are transported through tubing at high pressure, ready for storage or direct use. The underground production leverages geothermal energy, hydrostatic pressure, and well structures for both production and storage, offering a cost-effective, energy-efficient, and low-emission alternative to conventional electrolysis methods.

Company name DeepH2 Inc (USA)

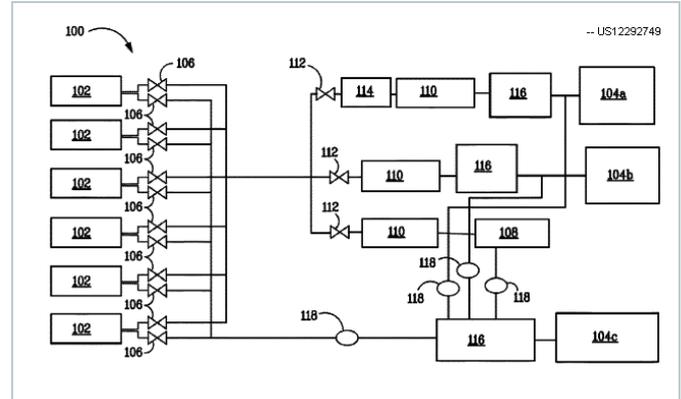
Inventors Gates Ian,
Macrae Hugh,
Wang Jingyi

Priority date 27-Jan-2022

Publication date 08-May-2025

◀ **US12292749B2**

Multiple output header



This invention discloses a versatile gas distribution system designed to efficiently supply gases particularly hydrogen to multiple applications requiring different pressure levels. It includes multiple gas generators e.g., PEM electrolyzers with specific output pressures, connected via header valves to various applications with differing header pressures. A key innovation is the dynamic control of gas flow using a controller that automatically opens or closes header valves in response to real-time pressure change, optimizing delivery without unnecessary compression or energy loss. This design eliminates inefficiencies from over-compression and unnecessary decompression by enabling intelligent, flexible distribution of gases like hydrogen across multiple end uses.

Company name Ohmium International Inc (USA)

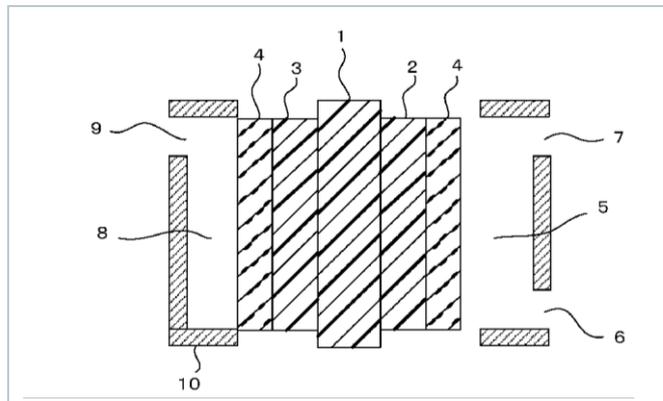
Inventors Ballantine Arne,
Karuppaiah Chockkalingam,
Aghatehrani Rasool,
Worster Roby,
Mueller Celeste

Priority date 17-Jun-2021

Publication date 06-May-2025

◀ **JP2025078675A**

Ion exchange membrane, polyolefin-based porous membrane, membrane electrode assembly, water electrolysis device, and method for producing polyolefin-based porous membrane



This invention relates to a durable, low-resistance ion exchange membrane designed for use in water electrolysis devices. The core innovation lies in using a specially structured polyolefin-based porous membrane as a support, which significantly enhances the toughness of the ion exchange membrane while reducing its electrical resistance. By optimizing properties like tear strength and dimensional stability (even under repeated swelling and drying), the membrane resists mechanical failure and extends the operational life of electrolysis devices. The invention also includes a novel manufacturing method for the porous membrane, ensuring consistent performance.

Company name Tokuyama Corp (Japan)

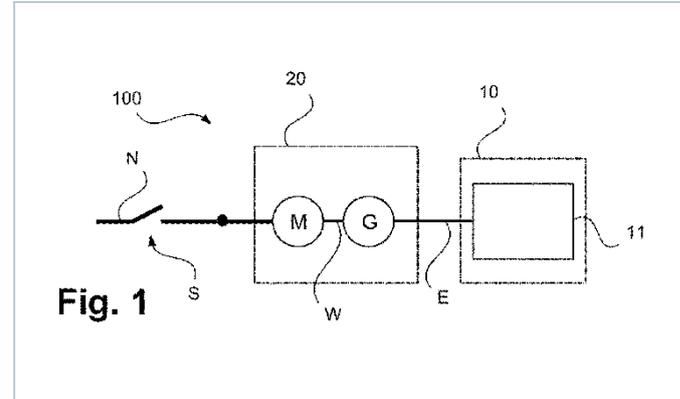
Inventors Sugata Masami,
Mishima Yu

Priority date 20-Mar-2023

Publication date 20-May-2025

◀ EP4559065A1

Method and plant for producing hydrogen



This invention describes a flexible and energy-efficient system for producing hydrogen using water electrolysis powered by AC current from the grid. Instead of conventional power electronics, it uses a combination of two electrically coupled synchronous machines one operating as a motor and the other as a generator to convert AC into DC for the electrolysers. This setup, known as a synchronous motor-generator set (SMGS), helps in reducing the network disturbances such as harmonics and reactive power demand, which are common with traditional rectifiers. It also improves grid stability by acting as a buffer for power fluctuations and can operate in reverse to feed power back into the grid using stored hydrogen in fuel cells. The invention supports multiple electrolysis types and reduces the need for costly filtering or compensation equipment.

Company name Linde GMBH (Germany)

Inventors Peschel Andreas,
Liebhart Christian

Priority date 20-Jul-2022

Publication date 28-May-2025

EP4558664A1

Energy efficient Lithium Chloride electrolytic process and electrolyzer plant

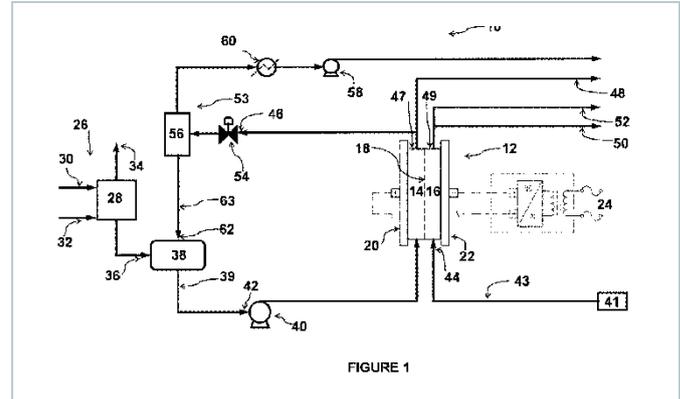


FIGURE 1

This invention presents an energy-efficient apparatus and method for producing lithium hydroxide (LiOH) from lithium chloride (LiCl) via electrolysis. It includes an electrolyzer cell with an anolyte and catholyte compartment separated by an ion exchange membrane. A key innovation is the use of a vacuum flash evaporator to concentrate the diluted anolyte from electrolysis by reusing heat from the electrolyzer, which reduces the need for extra energy. The concentrated anolyte is then recirculated to the electrolyzer, minimizing waste and improving water balance. This design lowers energy consumption, reduces equipment size, limits water usage, and avoids sending lithium species back to brine treatment systems, making the process more cost-effective and environmentally sustainable.

Company name Noram Electrolysis Systems Inc (Canada)

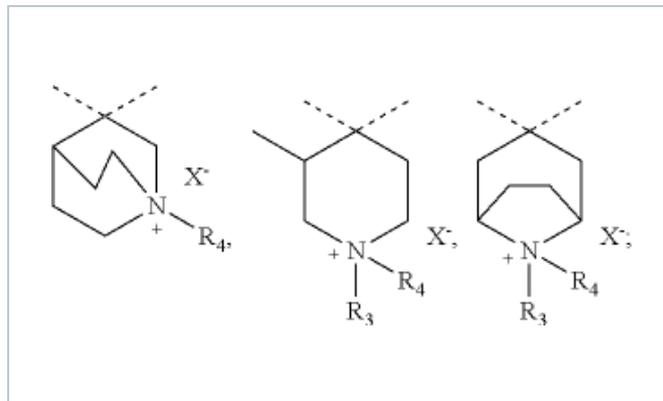
Inventors Brereton Clive,
Wolfs Warren,
Bailey Ian

Priority date 11-May-2023

Publication date 28-May-2025

◀ IN202517019610A

Nitrogen-containing heterocyclic polymer, and polymer film and use thereof vehicle



This invention introduces a new type of polymer material used to make membranes that are more stable and efficient in harsh chemical environments, like strong acids or bases. These membranes help control the flow of ions, which is important for technologies like fuel cells, hydrogen production, batteries, and water treatment. These membranes are made from nitrogen-containing heterocyclic polymers using compounds like 3-quinuclidinone, N-alkyl-3-methyl-4-piperidone, and 8-alkyl-8-azabicyclooctan-3-one, which are low-cost, easy to store, and suitable for large-scale production. Their unique structure gives them excellent durability, making them ideal for long-term use in demanding chemical environments.

Company name Wuhan Limo Technology Co Ltd (China)

Inventors Li Ming,
Liu Junyu,
Liao Yunlan

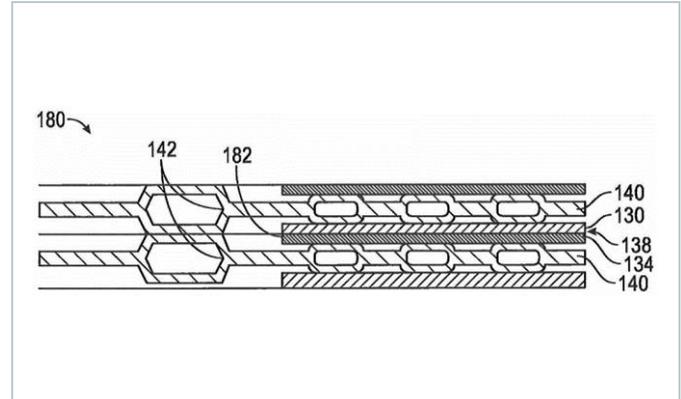
Priority date 20-Sep-2022

Publication date 16-May-2025



DE102024101502B3 Green

Membrane electrode arrangement



The invention addresses key limitations in electrochemical systems by introducing an improved membrane electrode assembly (MEA) for fuel cells and electrolyzers. Traditional MEAs often face issues like gas crossover, reduced durability, and declining performance under operational stress. This invention enhances MEA performance through a novel Proton Exchange Membrane (PEM) structure that includes gas recombination layers, ionomer layers, and multiple reinforcement layers. These elements work together to improve mechanical strength, reduce cracking, and minimize gas crossover. Additionally, the optimized distribution of catalysts within the gas recombination layers boosts overall efficiency and extends the lifespan of the electrochemical system.

Company name GM Global Technology Operations LLC (USA)

Inventors lang Ruichun,
Kumaraguru Swaminatha P

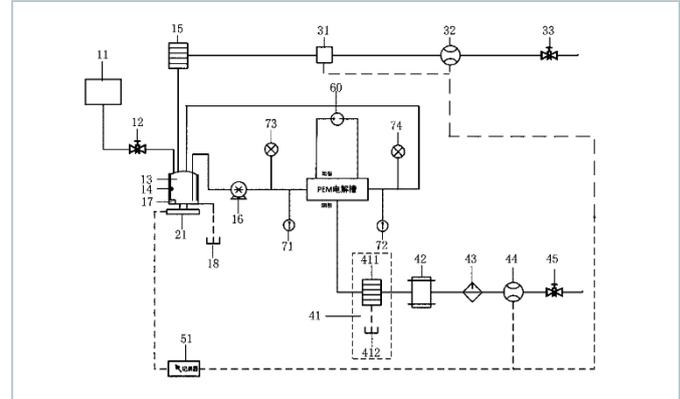
Priority date 28-Nov-2023

Publication date 15-May-2025



◀ **CN120020278A**

PEM (PEM) electrolytic tank testing system and method



The invention addresses the difficulty of accurately measuring the permeation of hydrogen and water through the Proton Exchange Membrane (PEM) during operation, which is critical for optimizing electrolyser design. It introduces a comprehensive testing system comprising interconnected modules for power supply, water supply, water storage and exhaust, and hydrogen production monitoring. These modules enable precise, real-time tracking of key parameters such as deionized water input and residuals, mixed gas composition, and hydrogen output. By capturing detailed operational metrics, it improves the accuracy of anode and cathode permeation measurements, facilitating better design, control, and performance optimization of PEM electrolytic cells.

Company name	Tehi Hydrogen Energy Testing Baoding Co Ltd (China)
Inventors	Li Jinsheng, Ma Pengfei, Li Xiaoliang, Zhao Ruiming, Wang Hailong
Priority date	20-Nov-2023
Publication date	20-May-2025

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