

# **Polymer Electrolyte Membrane (PEM) Fuel Cell Market – Global Industry Size, Share, Trends, Opportunity, and Forecast Segmented By End Use (Automotive, Industrial, Commercial, Residential), By Application (Stationary, Portable, Transport), By Region, Competition 2018-2028**

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## **Abstracts**

The Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market, valued at USD 2.74 billion in 2022, is poised for robust growth in the forecast period with an anticipated CAGR of 16.25% through 2028. This market encompasses the worldwide industry engaged in researching, developing, manufacturing, and deploying PEM fuel cell systems and associated components. PEM fuel cells represent a class of electrochemical devices that produce electricity by catalyzing the reaction between hydrogen and oxygen, facilitated by a polymer electrolyte membrane. Renowned for their high energy efficiency, minimal emissions, and capacity to provide clean and dependable power, these fuel cells find application across diverse sectors.

A Polymer Electrolyte Membrane Fuel Cell, commonly known as a PEM fuel cell, operates as an electrochemical device that converts the chemical energy derived from hydrogen and oxygen into electricity, along with the generation of water and heat through an electrochemical process. This process unfolds within a stack of individual cells, each housing a proton-conductive polymer electrolyte membrane. PEM fuel cells serve as a clean and efficient alternative to internal combustion engines and are employed in fuel cell electric vehicles (FCEVs), powering various forms of transportation such as cars, buses, and trucks. Additionally, PEM fuel cells are deployed for stationary power generation across residential, commercial, and industrial domains. They serve purposes like backup power supply, combined heat and power (CHP) systems, and

support for the electrical grid.

In the realm of portable electronic devices, small-scale PEM fuel cells are instrumental in powering gadgets like laptops, smartphones, and camping equipment, offering extended and environmentally-friendly energy sources. Furthermore, critical infrastructure, data centers, and telecom base stations rely on PEM fuel cells for backup power to ensure uninterrupted operations during power interruptions. Within the logistics and material handling sphere, PEM fuel cells power equipment such as forklifts and pallet jacks in warehouses and distribution centers.

The PEM fuel cell market is in a constant state of evolution due to technological advancements, escalating environmental concerns, and the pursuit of clean energy solutions. It plays an instrumental role in steering the transition towards a more sustainable and low-carbon energy landscape, presenting a promising alternative to conventional fossil fuel-based power generation and transportation systems.

### Key Market Drivers

The Polymer Electrolyte Membrane (PEM) Fuel Cell Market is a segment of the clean energy industry that focuses on the development, manufacturing, and deployment of PEM fuel cell systems. PEM fuel cells are known for their high energy efficiency, low emissions, and suitability for various applications, including transportation, stationary power generation, and portable devices. The market is influenced by several key drivers that impact its growth and development. Here are the primary drivers of the PEM fuel cell market: The global push for clean and sustainable energy sources to mitigate climate change and reduce greenhouse gas emissions is a major driver of the PEM fuel cell market. PEM fuel cells produce electricity through a chemical reaction between hydrogen and oxygen, emitting only water vapor as a byproduct, making them a clean energy source. The transportation sector represents a significant opportunity for PEM fuel cells, particularly in fuel cell electric vehicles (FCEVs). Governments and automakers are investing in FCEV technology as an alternative to internal combustion engines, driven by the need to reduce carbon emissions and improve air quality. The development of a hydrogen economy, where hydrogen is produced, stored, and used as an energy carrier, is a strong driver for PEM fuel cells. Hydrogen can be produced from various sources, including renewable energy, and used in fuel cells to generate electricity efficiently. PEM fuel cells can play a role in energy storage applications, such as grid-level energy storage and backup power systems. The need for reliable and efficient energy storage solutions to balance intermittent renewable energy sources drives the market.

## Decentralized Energy Generation

PEM fuel cells can be used for distributed or decentralized energy generation. They are well-suited for combined heat and power (CHP) applications, providing both electricity and heat for residential and commercial buildings. Supportive government policies, incentives, and subsidies aimed at promoting clean energy technologies, including fuel cells, encourage investment and adoption of PEM fuel cell systems.

## Research and Development

Ongoing research and development efforts to improve the performance, durability, and cost-effectiveness of PEM fuel cell technology are driving advancements in the market. Innovations in materials and manufacturing processes contribute to market growth. Collaboration between countries and international organizations on hydrogen and fuel cell research and development fosters innovation and expands market opportunities. As PEM fuel cell technology matures, it finds applications beyond traditional uses. This includes backup power for telecom infrastructure, off-grid power generation, and small-scale portable fuel cells for consumer electronics. Increasing awareness of clean energy solutions and environmental concerns among consumers and businesses has led to a growing interest in PEM fuel cells as a sustainable and efficient energy source. The expansion of hydrogen refueling infrastructure for FCEVs is a crucial driver for the adoption of PEM fuel cell vehicles. Investments in infrastructure are essential to support the growth of the market. High-profile demonstration projects and pilot programs that showcase the capabilities and benefits of PEM fuel cell technology help build confidence and drive market acceptance.

## Key Market Challenges

### High Manufacturing Costs

One of the primary challenges for PEM fuel cells is their relatively high manufacturing costs, primarily attributed to the use of expensive catalyst materials, such as platinum, in the electrodes. Reducing these costs is essential to make PEM fuel cells more competitive with other energy sources. PEM fuel cells must operate efficiently for extended periods to be economically viable. Ensuring the long-term durability and longevity of fuel cell components, especially the proton-conducting membrane and catalysts, is a significant challenge. The catalysts used in PEM fuel cells are sensitive to factors like contaminants, fuel impurities, and high-voltage cycling. Catalyst degradation

can significantly impact the performance and lifespan of the fuel cell. Hydrogen is the primary fuel for PEM fuel cells, and its storage, transportation, and distribution remain significant challenges. Developing efficient, safe, and cost-effective hydrogen infrastructure is essential for the market's growth. The lack of a comprehensive hydrogen fueling infrastructure is a challenge, particularly for the widespread adoption of fuel cell vehicles. Expanding hydrogen refueling stations requires significant investment and coordination. The majority of hydrogen production relies on fossil fuels, which contradicts the goal of clean energy. Developing scalable and sustainable hydrogen production methods, such as electrolysis using renewable energy sources, is a challenge. PEM fuel cells require proper water management to prevent dehydration or flooding of the proton-conducting membrane. Balancing water content within the fuel cell is critical for optimal performance.

### Cold Start and Freezing

Operating PEM fuel cells in cold weather conditions can be challenging due to the potential for water freezing within the cell. Developing effective heating and insulation solutions is essential for cold-weather applications. Transitioning from laboratory-scale prototypes to large-scale commercial production is often challenging. Ensuring consistent performance and reliability at scale is a significant hurdle for PEM fuel cell manufacturers. Hydrogen is flammable and poses safety concerns, particularly in transportation applications. Ensuring the safe handling, storage, and use of hydrogen is critical for public acceptance. PEM fuel cells face competition from other clean energy technologies, such as lithium-ion batteries and solid oxide fuel cells, which offer different advantages and may be better suited for certain applications. Inconsistent regulatory frameworks and policies regarding hydrogen and fuel cell technologies can hinder market growth. Clear and supportive regulations are necessary to incentivize adoption. Raising awareness and fostering public trust in fuel cell technology is a challenge. Public perception and understanding of fuel cells, especially in comparison to well-established technologies like internal combustion engines, can impact adoption rates.

Despite these challenges, ongoing research and development efforts, government support, and collaborations between industry and academia are addressing many of these issues. As technology advances, and as clean energy goals become more critical, PEM fuel cells are expected to play a significant role in achieving sustainable and efficient energy solutions. Overcoming these challenges will be essential for the PEM fuel cell market to reach its full potential and contribute to a cleaner and more sustainable energy future.

## Key Market Trends

### Government Initiatives and Growing Private Investments are Expected to Drive the Market

The PEM fuel cell market witnessed significant growth in the last two years, mainly due to the introduction of government initiatives in key markets and increasing investment support from the private sector. The Californian Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program, a government initiative in 2013, established long-term authority to co-fund the first 100 retail hydrogen stations. This encouraged the private sector to invest in the fuel cell market. The Californian Fuel Cell Partnership aims for a network of 1,000 hydrogen stations and a fuel cell vehicle population of up to 1,000,000 vehicles by 2030. The target reflects the input and consensus of more than 40 partners, including fuel cell technology companies, automakers, energy companies, government agencies and non-governmental organizations, and universities. In February 2022, a project showed that high-temperature polymer electrolyte membrane fuel cells (HT-PEMFCs) offer an attractive solution to electrify heavy-duty vehicles and other large-scale mobility applications due to effective heat rejection. Moreover, multiple institutions, including LANL (Katie Lim), Sandia National Labs (Cy Fujimoto), Korea Institute of Science and Technology (Jiyoon Jung), University of New Mexico (Ivana Gonzales), University of Connecticut (Jasna Jankovic), and Toyota Research Institute of North America (Zhendong Hu and Hongfei Jia) were involved in this project. Among fuel cells, the PEM type is the most popular one. It is expected to play a crucial role in Europe's target for fuel cell deployment and drive the PEM fuel cells market.

In February 2022, scientists of the Los Alamos National Laboratory developed a new polymer fuel cell that operates at higher temperatures. The long-standing issue of overheating, one of the biggest technical obstacles to using medium- and heavy-duty fuel cells in vehicles, such as trucks and buses, was resolved by a new high-temperature polymer fuel cell that operates at 80-160 degrees Celsius and has a higher rated power density than cutting-edge fuel cells. Furthermore, there is a rise in fuel cell-based vehicle demand worldwide. North Korea and the United States are the leading countries in the world in terms of stock of fuel cell-based vehicles. In 2021, North Korea and the United States had 38% and 24% of world fuel cell-based vehicle stock, respectively. Hence, such government initiatives and investments are likely to propel the market during the forecast period. Therefore, owing to the abovementioned factors, government initiatives and growing private investments in PEMFC technology are expected to drive the market during the forecast period.



## Segmental Insights

### End Use Insights

The automotive segment is the largest segment of the PEM fuel cell market. The demand for PEM fuel cells in the automotive segment is being driven by the increasing environmental concerns and the need for cleaner and more sustainable transportation solutions. PEM fuel cells are used in fuel cell-powered vehicles, such as buses, cars, and trucks. The industrial segment is the second largest segment of the PEM fuel cell market. The demand for PEM fuel cells in the industrial segment is being driven by the need for backup power systems and energy storage solutions. PEM fuel cells are used in a variety of industrial applications, such as data centers, telecommunications, and manufacturing. The commercial segment is the third largest segment of the PEM fuel cell market. The demand for PEM fuel cells in the commercial segment is being driven by the need for backup power systems and energy storage solutions. PEM fuel cells are used in a variety of commercial applications, such as hospitals, hotels, and shopping malls. The residential segment is the smallest segment of the PEM fuel cell market. The demand for PEM fuel cells in the residential segment is being driven by the need for backup power systems and energy storage solutions. PEM fuel cells are used in a variety of residential applications, such as homes and apartments.

### Regional Insights

The Asia Pacific region has established itself as the leader in the Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market with a significant revenue share in 2022. The Asia-Pacific is one of the promising regional markets for polymer electrolyte membrane fuel cells due to favorable government policies for clean energy usage in countries such as China, Japan, and South Korea. China is considered to have the highest potential for PEMFC as the hydrogen fuel cell industry in the country has been gaining traction on the back of favorable national and provincial government subsidies and incentive programs from local authorities, mainly to encourage the uptake of hydrogen vehicles to cut pollution. Along with the potentially large market, China has numerous domestic enterprises that manufacture PEMFC. Hence, the country's demand and domestic supply are present, further bolstering the growth of the market. Moreover, Chinese companies seek to build their electrolyzer manufacturing capacity to 1.5-2.5 GW in 2022 to supply domestic and overseas markets. Therefore, owing to the abovementioned factors, the Asia-Pacific is expected to dominate the market during the forecast period.

## Key Market Players

Ballard Power System

Plug Power

Bloom Energy

FuelCell Energy

Hydrogenics (now part of Cummins Inc.)

Nuvera Fuel Cells

Doosan Fuel Cell America

Nel Hydrogen

Advent Technologies

SFC Energy

## Report Scope:

In this report, the Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market has been segmented into the following categories, in addition to the industry trends which have also been detailed below:

Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market, By End Use :

Automotive

Industrial

Commercial

Residential

## Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market, By Application:

Stationary

Portable

Transport

## Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market, By Region:

North America

United States

Canada

Mexico

Asia-Pacific

China

India

Japan

South Korea

Indonesia

Europe

Germany

United Kingdom

France



Russia

Spain

South America

Brazil

Argentina

Middle East & Africa

Saudi Arabia

South Africa

Egypt

UAE

Israel

## Competitive Landscape

Company Profiles: Detailed analysis of the major companies present in the Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market.

## Available Customizations:

Global Polymer Electrolyte Membrane (PEM) Fuel Cell Market report with the given market data, Tech Sci Research offers customizations according to a company's specific needs. The following customization options are available for the report:

## Company Information

Detailed analysis and profiling of additional market players (up to five).

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