

# Hydrogen Fuel Cell Market: Focus on Application, Product Type, Technology, and Country-Level Analysis - Analysis and Forecast, 2023-2033

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## Abstracts

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### Introduction of Hydrogen Fuel Cell

In the field of renewable energy, hydrogen fuel cells are a viable and sustainable technology. The primary benefits of hydrogen fuel cells are their environmental friendliness and efficiency, which make them a clean substitute for conventional combustion-based power sources. Hydrogen is an energy carrier with great versatility that may be obtained from a range of renewable resources. For example, water electrolysis can be achieved by using electricity generated from renewable sources such as solar or wind power. Applications for hydrogen fuel cells can be found in several industries, including transportation, where they power cars that only release water vapor. Hydrogen fuel cell technology is constantly developing, which adds to its potential to be a major player in a future with lower carbon emissions and more sustainable energy.

### Market Introduction

The early days of hydrogen fuel cell adoption were defined by cautious optimism and innovative thinking, as well as substantial scientific advancements and the promise of a clean energy future. Hydrogen fuel cells, which were initially expected in the nineteenth century, had their first practical usage during NASA's space missions in the 1960s and provided astronauts with a stable supply of power and water. However, commercial adoption has been delayed and hampered by technological obstacles, high prices, and

a lack of infrastructure. Despite these challenges, the early 2000s saw a revived interest in hydrogen fuel cells, spurred by the rising need to discover sustainable energy solutions and decrease carbon emissions. Although adoption was slow and difficult at first, early acceptance of hydrogen fuel cells established the framework for the technology's continued progress and crucial role in today's global goal of a zero-emission future.

Considering the current circumstances, there is a global upsurge in interest and use of hydrogen fuel cells, signifying an evolution in the energy sector. Governments and companies are driving initiatives to incorporate fuel cell technologies across multiple sectors as they become more aware of hydrogen's potential as a clean and adaptable energy source. Notably, the automotive industry is witnessing a growing number of hydrogen fuel cell vehicles on the market, with major players investing in infrastructure development to support their adoption. At the same time, fixed uses such as industrial processes and backup power systems are profiting from hydrogen fuel cells' sustainability and dependability. The focus on reaching net-zero emissions by the international community and the rise of green hydrogen produced from renewable resources further emphasize the critical role that hydrogen fuel cells play in the shift to a low-carbon emission future. Despite obstacles, the present trend indicates that hydrogen fuel cells, which provide a more sustainable and cleaner substitute for traditional power sources, have the potential to play a significant role in changing the energy landscape.

## Industrial Impact

The industrial impact of hydrogen fuel cells is becoming increasingly pronounced as the world grapples with the imperative to reduce carbon emissions and transition towards sustainable energy solutions. Hydrogen fuel cells are transforming the industrial sector by providing a clean and effective power source for a range of uses. They are useful for supplying dependable, emission-free electricity to manufacturing facilities and warehouses, as well as for powering material handling equipment. Furthermore, the usage of hydrogen fuel cells in the transportation industry is growing, especially in heavy-duty vehicles such as buses and trucks, where they offer a competitive alternative to conventional fossil fuel-powered engines. Hydrogen fuel cells are being investigated by energy-intensive industries, including petrochemical and chemical manufacturing, because of their potential to decarbonize processes and support a more sustainable production ecosystem. In the pursuit of cleaner, greener, and more robust operations, hydrogen fuel cells are becoming an increasingly important part of industrial strategies as governments and organizations around the world commit to dedicated

carbon reduction targets. Hydrogen fuel cell technologies are still being researched, developed, and used, which highlights their potential to completely transform industrial processes and make a substantial contribution to a low-carbon emission future.

## Market Segmentation:

### Segmentation 1: by Application

Stationary Power

Portable Power

Transport

Passenger Cars

Commercial Vehicles

Others

### Transport Segment to Dominate the Global Hydrogen Fuel Cell Market (by Application)

The hydrogen fuel cell market is led by the transport segment, with a 78.78% share in 2022. Increasing potential for integration with other renewable technologies by the military and defense industry is driving the growth of the hydrogen fuel cell market.

### Segmentation 2: by Product Type

Liquid-Cooled Type

Air-Cooled Type

### Liquid-Cooled Type Segment to Dominate the Global Hydrogen Fuel Cell Market (by Product Type)

Based on product type, the hydrogen fuel cell market is led by the liquid-cooled type segment, which held a 61.86% share in 2022.

### Segmentation 3: by Technology

Polymer Electrolyte Membrane (PEM)

Alkaline (AFC)

Phosphoric Acid (PAFC)

Molten Carbonate (MCFC)

Solid Oxide (SOFC)

Polymer Electrolyte Membrane (PEM) Segment to Dominate the Global Hydrogen Fuel Cell Market (by Technology)

Based on technology, the hydrogen fuel cell market is led by the polymer electrolyte membrane (PEM) segment, which held a 77.11% share in 2022.

### Segmentation 4: by Region

North America - U.S., Canada, Mexico

Europe - U.K., Germany, France, Spain, Italy, and Rest-of-Europe

Asia-Pacific - Japan, India, China, South Korea, and Rest-of-Asia-Pacific

Rest-of-the-World - South America and Middle East and Africa

Europe hydrogen fuel cell market was the highest-growing market among all the regions, registering a CAGR of 24.01%. North America is anticipated to gain traction in terms of hydrogen fuel cell adoption as well as the introduction of newer methods owing to the growing demand for clean energy among the countries. Moreover, favorable government policies are also expected to support the growth of the hydrogen fuel cell market in North America and Europe during the forecast period.

In Europe, Germany is anticipated to show the highest growth in the hydrogen fuel cell

market among other countries and is anticipated to grow at a CAGR of 27.18%. The growth of Germany in the hydrogen fuel cell market is mainly due to the fact that Germany is home to some of the most renowned automobile companies, and with the growing demand for electric vehicles as well as cleaner fuels, the demand for the hydrogen fuel cell is set to witness a growth in demand during the forecast period.

### Recent Developments in the Hydrogen Fuel Cell Market

In October 2023, Horizon Fuel Cell delivered a containerized 2MW PEM fuel cell "Combined Heat and Power" (CHP) system and plans to deploy zero-emission stationary powerplants up to 100MW.

In February 2023, Nedstack Fuel Cell Technologies signed a partnership with ZBT. Under this, Nedstack and ZBT agreed to a close collaboration in order to industrialize hydrogen fuel cell technology.

### Demand – Drivers and Limitations

#### Market Demand Drivers: Decarbonization Targets and Environmental Regulations

Hydrogen fuel cells have arisen as a vital technology in the field of renewable energy, driven in large part by the urgent need for decarbonization and strict environmental legislation. These issues have evolved from difficulties to key commercial drivers for companies in the hydrogen fuel cell market. The fight for a more sustainable future is altering the energy landscape, making hydrogen an indicator of optimism and potential.

#### Market Challenges: High Initial Investment Costs

While the hydrogen fuel cell sector has tremendous potential, it is hampered by high initial investment costs. This is a complex conflict that affects many areas of the hydrogen value chain, from production to infrastructure development. The first barrier is the production of hydrogen. The most popular technique of producing hydrogen nowadays is steam methane reforming, which is quite inexpensive but not ecologically benign. Green hydrogen production, which incorporates electrolysis driven by renewable energy, is more environment-friendly but more expensive owing to advanced technology and energy needs.

#### Market Opportunities: Integration Services for Renewable Energy Systems

Renewable energy system integration represents a substantial business potential for enterprises in the hydrogen fuel cell industry, providing a path to a more linked and efficient energy environment. This integration is critical to realizing the full potential of hydrogen fuel cells because it enables the development of a holistic energy solution that tackles the storage, distribution, and application difficulties associated with renewable energy sources such as solar and wind.

How can this report add value to an organization?

**Product/Innovation Strategy:** The product segment helps the reader understand the different product types and technologies available for deployment and their potential globally. Moreover, the study provides the reader with a detailed understanding of the hydrogen fuel cell market by application on the basis of application (stationary power, portable power, transport) and product on the basis of product type (liquid-cooled type, air-cooled type), by technology (polymer electrolyte membrane (PEM), alkaline (AFC), phosphoric acid (PAFC), molten carbonate (MCFC), solid oxide (SOFC)).

**Growth/Marketing Strategy:** The hydrogen fuel cell market has seen major development by key players operating in the market, such as business expansion, partnership, collaboration, and joint venture. The favored strategy for the companies has been merger and acquisition to strengthen their position in the hydrogen fuel cell market. For instance, in January 2024, General Motors and Honda Motor announced that they had commenced commercial manufacturing of hydrogen fuel cell systems, a step toward providing zero-emission alternatives to battery-electric vehicles. The fuel cell systems would be manufactured in a 50-50 joint venture between the automakers at a \$85 million facility in suburban Detroit. The firms, who promote and sell their goods independently, describe the joint venture's "large-scale" production as the first of its sort in the U.S.

**Competitive Strategy:** Key players in the hydrogen fuel cell market analyzed and profiled in the study involve major hydrogen fuel cell offering companies for various applications. Moreover, a detailed competitive benchmarking of the players operating in the hydrogen fuel cell market has been done to help the reader understand how players stack against each other, presenting a clear market landscape. Additionally, comprehensive competitive strategies such as partnerships, agreements, and collaborations will aid the reader in understanding the untapped revenue pockets in the market.

**Methodology:** The research methodology design adopted for this hydrogen fuel cell market study includes a mix of data collected from primary and secondary data sources. Both primary resources (key players, market leaders, and in-house experts) and secondary research (a host of paid and unpaid databases), along with analytical tools, are employed to build the predictive and forecast models.

Data and validation have been taken into consideration from both primary sources as well as secondary sources.

### Key Considerations and Assumptions in Market Engineering and Validation

Detailed secondary research has been done to ensure maximum coverage of manufacturers/suppliers operational in a country.

Exact revenue information, up to a certain extent, has been extracted for each company from secondary sources and databases. Revenues specific to product/service/technology have then been estimated for each market player based on fact-based proxy indicators as well as primary inputs.

Based on the classification, the average selling price (ASP) has been calculated using the weighted average method.

The currency conversion rate has been taken from the historical exchange rate of Oanda and/or other relevant websites.

Any economic downturn in the future has not been taken into consideration for the market estimation and forecast.

The base currency considered for the market analysis is US\$. Currencies other than the US\$ have been converted to the US\$ for all statistical calculations, considering the average conversion rate for that particular year.

The term “product” in this document may refer to “service” or “technology” as and where relevant.

The term “manufacturers/suppliers” may refer to “service providers” or “technology providers” as and where relevant.



## Primary Research

The primary sources involve industry experts from the transportation and energy sector industry, including hydrogen fuel cell manufacturers and providers for different industries. Respondents such as CEOs, vice presidents, marketing directors, and technology and innovation directors have been interviewed to obtain and verify both qualitative and quantitative aspects of this research study.

## Secondary Research

This study involves the usage of extensive secondary research, company websites, directories, and annual reports. It also makes use of databases, such as Spacenews, Businessweek, and others, to collect effective and useful information for a market-oriented, technical, commercial, and extensive study of the global market. In addition to the data sources, the study has been undertaken with the help of other data sources and websites, such as [www.nasa.gov](http://www.nasa.gov).

Secondary research was done to obtain critical information about the industry's value chain, the market's monetary chain, revenue models, the total pool of key players, and the current and potential use cases and applications.

## Key Market Players and Competition Synopsis

The companies that are profiled in the hydrogen fuel cell market report have been selected based on thorough secondary research, which includes analyzing company coverage, product portfolio, market penetration, and insights gathered from primary experts.

The hydrogen fuel cell market comprises key players who have established themselves thoroughly and have the proper understanding of the market, accompanied by start-ups who are looking forward to establishing themselves in this highly competitive market. In 2022, the hydrogen fuel cell market was dominated by established players, accounting for 75% of the market share, whereas the start-ups managed to capture 25% of the market. With the growing aviation and automotive industry, more players are expected to enter the global hydrogen fuel cell market with each passing year.

Some prominent names established in the hydrogen fuel cell market are:

Panasonic



Ballard Power Systems

TW Horizon Fuel Cell Technologies

Ceres

Toshiba America Energy Systems Corporation (TAES)

Plug Power Inc.

Nikola Corporation

Mitsubishi Hitachi Power Systems

Shanghai Pearl Hydrogen Energy Technology Co.

FuelCell Energy, Inc.

AFC Energy

Nedstack Fuel Cell Technology

Doosan Fuel Cell Co., Ltd.

Bloom Energy

KYOCERA Corporation

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