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Green Hydrogen Market Assessment, By Technology [Proton Exchange Membrane Electrolyzer, Alkaline Electrolyzer, Solid Oxide Electrolyzer, Polymer Electrolyte Membrane Electrolyzer], By Renewable Source [Solar, Wind, Hydropower, and Others], By Transportation Channel [Roadways, Waterways, Pipelines], By End-user [Power Generation, Transportation, Chemicals & Petrochemicals, Steel, Food & Beverages, Medical, and Others], and By Region, Opportunities and Forecast, 2016-2030F

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Abstracts

Global Green Hydrogen Market size was valued at USD 2.2 billion in 2022 and is projected to reach USD 24.46 billion by 2030, growing at a CAGR of 35.13% from 2023 to 2030. Energy is pivotal for global development, economy, and sustainability, powering industries, transportation, and meeting daily needs. However, rising energy demand raises environmental concerns due to greenhouse gas emissions and climate change impacts.

Green hydrogen is a promising solution to address the environmental impact of increasing energy demands. It is produced using renewable sources and offers a clean alternative for industries, transportation, and daily needs. Carbon-neutral, it combats greenhouse gas emissions and aligns with global goals, paving the way for an eco-friendly, sustainable energy future.

In January 2023, the global industry unveiled over 1,000 large-scale project proposals.

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Among them, 795 projects intend to be fully or partially operational by 2030, with combined investments amounting to USD 320 billion in hydrogen value chains through 2030. Companies globally have revealed plans to produce 38 million metric tons of clean hydrogen annually (MMTPA) by 2030. The production plans comprise both low-carbon and renewable hydrogen, with approximately half of the projects currently in the planning stage or having secured capital commitments.

Green hydrogen is gaining popularity as countries and industries transition to carbon neutrality. Driven by declining costs, technological advancements, supportive policies, and public awareness, governments, businesses, and individuals are adopting green hydrogen solutions to reduce emissions, improve air quality, and achieve energy independence.

Green Hydrogen Serves as the Future Fuel

The Paris Agreement aims to limit global warming to 2 degrees Celsius, with 70 countries, including major polluters like China, the US, and the EU, committing to net-zero emissions. Countries like the UK, Japan, USA, and EU aim to achieve net zero by 2050.

Green Hydrogen is a crucial solution for global net-zero targets, offering significant reductions in greenhouse gas emissions. In the NZE Scenario, low-emission hydrogen and hydrogen-based fuels offer modest CO2 reductions in 2030. However, they are essential in heavy industry, long-distance transport, shipping, and aviation sectors, with more significant impact as hydrogen technologies advance.

Replacing fossil fuel-based hydrogen with low-emission hydrogen is a priority for refining and industry applications, as emissions intensity is projected to decrease from 12-13.5 kg CO2-eq per kg H2 in 2022 to 6-7.5 kg CO2-eq per kg H2 in 2030. The Green Hydrogen market is growing. Bloom Energy and LSB Industries are partnering to install a 10 MW solid oxide electrolyzer in their Pryor, Oklahoma plant, producing green hydrogen for 13,000 metric tons of zero-carbon ammonia annually.

Technological Innovations Boost Green Hydrogen's Potential

Europe and North America are the primary markets for announced hydrogen supply, with 13 MTPA and 9 MTPA, respectively. By 2025, North America will lead in terms of volume, boasting 2.8 million metric tons per annum (MTPA), of which a substantial 70% will be low-carbon hydrogen. Europe leads in announced volumes, while other regions

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have a higher share of mature volumes. About 40% of the total announced supply in China is committed from green hydrogen by 2025.

Advances in hydrogen production technologies, like electrolyzers, have made green hydrogen more economically viable and competitive with conventional energy sources. Green hydrogen is free from fossil fuels and offers a superior long-term solution for decarbonizing economies. However, its current cost in certain regions is higher than grey hydrogen. Over 230 GW of electrolysis deployment is announced for 2030, with 120 GW mature and feasibility studies underway. China leads in electrolysis capacity, followed by North America and Europe.

The decreasing renewable energy costs, economies of scale are realized, global commitments to green hydrogen projects, and technological advances will reduce the production cost, making green hydrogen a more cost-effective option.

Government Promotes Green Hydrogen as a Clean Energy Future

Governments globally actively support the development of green hydrogen through policy frameworks, incentives, and funding initiatives. This support helps accelerate its adoption and development as a clean energy solution.

All major economies have launched Green Hydrogen Strategies like the United States hydrogen tax credits under The United States Inflation Reduction Act (August 2022), which grants tax credits up to USD 3 per kg for clean hydrogen producers over a decade based on carbon emissions lifecycle. It aims to create four regional clean hydrogen hubs, fostering a national clean hydrogen economy and reducing green hydrogen costs to less than USD 2 per kg by 2026 (from over USD 5 per kg currently).

Similarly, the European Commission's Carbon Contracts for Difference (CCfD) program subsidizes green hydrogen, promoting a shift from natural gas to renewables. EU governments pay end users for not emitting carbon, aiming to produce 10 million tons of green hydrogen domestically and import another 10 MT by 2030. Germany's H2Global program, with USD 900 million funding, supports green ammonia, methanol, and sustainable aviation fuels. Similar initiatives exist in Australia, China, Canada, and India.

Growing Viability of Green Hydrogen

Green hydrogen becomes economically feasible as renewable energy costs decrease, integrating sectors like electricity, transport, and industry. It enhances energy efficiency

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and acts as energy storage, converting surplus renewable energy into hydrogen for electricity generation. The global clean hydrogen supply is around 800 KTPA, with 740 KTPA being low carbon, mainly in North America, and the rest being renewable.

Fuel cell electric vehicles (FCEV) sales reached 80,000 vehicles in the mobility and transportation industry, a 30% increase from 2022. OEMs announced over 130 FCEV models for 2023, mainly in China. Fuel cell global capacity is 12 GW, with Japan and South Korea as significant supply markets. Ammonia terminals are also increasing globally, with 38 export and 88 import terminals.

The NEOM Green Hydrogen Project, a joint venture between NEOM, Air Products, and ACWA Power, is the world's largest utility-scale green hydrogen facility powered by renewable energy. With a completion date of 2026, it will produce 600 tons of green hydrogen daily, saving 5 million tons of CO2 annually.

Infrastructure Development Enabling the Growth

Hydrogen infrastructure is expanding rapidly, laying the foundation for the green hydrogen market. Countries are investing in large-scale green hydrogen production facilities and embracing comprehensive hydrogen ecosystems to support various applications, such as developing hydrogen-powered urban transport systems and integrating hydrogen fuel cell buses and commercial vehicles. This growth promotes the widespread adoption of clean hydrogen as a sustainable and low-emission energy solution.

In 2021, Australia launched the Western Green Energy Hub project, a 50 GW renewable hydrogen facility, to supply green hydrogen to global markets. Shell plans to build a 100 MW electrolysis plant at the Rheinland refinery in Germany. Belgium's Port of Antwerp and the Netherlands' Port of Rotterdam collaborated on the H2MARES project to explore cross-border hydrogen pipeline connections, showcasing international hydrogen trade interest.

Development of hydrogen infrastructure, including storage facilities, transportation networks, and refueling stations, is crucial for building a global hydrogen economy and bolstering the green hydrogen market.

Impact of COVID-19

The COVID-19 pandemic significantly impacted the global energy sector, causing

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disruptions in demand, supply, and consumption patterns. Lockdowns, travel restrictions, and economic slowdowns led to a decline in energy demand, especially for transportation fuels. Industrial activities also contracted, causing reduced energy consumption and financial stress. Investment cuts in the oil and gas sector were also observed.

Despite the overall decline in energy demand, renewable energy sources, such as solar and wind, continued to grow and with them green hydrogen emerged as a promising solution to address climate change and promote a more sustainable energy future. Governments recognized the significance of green hydrogen and have started incorporating green hydrogen strategies into their long-term energy plans, emphasizing the role of clean energy in building a more resilient and low-carbon energy future.

Impact of Russia-Ukraine War

Russia ranks as the 3rd largest crude oil exporter in 2021. Europe, including Germany, the Netherlands, and Poland, is a major destination for Russian oil. The Ukraine war caused volatility in fossil fuel markets, prompting the deployment of clean energy technologies and a short-term scramble for oil and gas supply.

The conflict has led to countries diversifying their energy sources, with green hydrogen being a promising alternative. This global market offers domestic production using renewable resources, fostering technology transfer, knowledge sharing, and joint investments. Germany is part of the H2Med project, a hydrogen pipeline initiative connecting Spain, Portugal, France, and Germany, aiming to meet 10% of the European Union's hydrogen demand by 2030.

Key Players Landscape and Outlook

Key players focus on R&D to improve technologies, reduce production costs, and increase efficiency. They invest in large-scale projects and partnerships to drive market growth and expand global infrastructure. The German Federal Ministry for Economic Affairs and Climate Action initiated a procurement process for green hydrogen import under the H2Global program in December 2021. HINT.CO, an intermediary, will purchase hydrogen derivatives through competitive bidding, with deliveries to Germany and Europe scheduled for end-2024.

Similarly, the Spanish government has given the green light to ten significant projects, including Fertiberia and Iberdrola's Puertollano initiative. This project, operational since

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last year, has a production capacity of 200,000 tons of green hydrogen per year. Three Japanese companies, Marubeni Corporation, Iwatani Corporation, Kansai Electric Power Co., and Australian company Stanwell Corporation Limited and Singapore-based Keppel Infrastructure signed an agreement for the Central Queensland Hydrogen Project (CQ-H2). The project aims to produce, liquify, and export green hydrogen from Queensland, Australia, to Japan using renewable energy. Production and supply are expected to begin around 2030 with up to 640 MW of electrolyzers installed.

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Contents

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8. GLOBAL GREEN HYDROGEN MARKET OUTLOOK, BY REGION, 2016-2030F

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9. SUPPLY SIDE ANALYSIS

10. MARKET MAPPING, 2022

11. MACRO ENVIRONMENT AND INDUSTRY STRUCTURE

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