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Hydrogen Gas Storage Market Assessment, By State [Physical-based (Gas, Liquid, Others) and Material-based (Chemical Hydrogen, Adsorbent, Interstitial Hydride, Others)], By Storage Type [Pressurized Composite Vessels, Fiber Reinforced Composite Vessels, Cryo-Compressed Vessels, Others], By Technology [Geological Based, Compression, Liquefaction, Material Based, Others], By End-user [Energy & Industry (Nuclear Plant, Power Grids, Others), Mobility (Shipment, Heavy Transport, Others), Space Exploration, Others], By Region, Opportunities and Forecast, 2016-2030F

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Abstracts

The Hydrogen Gas Storage Market size was valued at USD 2511.14 million in 2022, expected to reach USD 4752.2 million in 2030 with a CAGR of 8.3% for the forecast period between 2023 and 2030. The hydrogen element is the first one in the periodic table, which is light, energy-dense, storable, and commensurate with its application in various forms across multi-domains. Unlikely other elements, hydrogen has the highest energy per mass compared to other fuels. Clean hydrogen is considered an essential source of fuel for various projects across the globe, and research is driving us to scale up technologies. In power generation, hydrogen storage leads to storing renewable energy, which can be used in gas turbines.

With the continuous global efforts to reduce emissions and the use of carbon-based

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fuels, the importance of hydrogen fuel cells can be accounted for as it assists in creating a greener solution to the power development projects, including small electronic devices to huge-carrying vehicles, aviation, and the human community. Hydrogen can be stored as liquid or gas according to the required applications. High-pressure tanks (5000-10000 psi) are usually needed for storing hydrogen in gaseous form, while cryogenic temperatures drive hydrogen storage in liquid form. Hydrogen can also be stored within solid materials or on the surface, called absorption and adsorption.

Demand for Hydrogen Storage Facilities

The various parameters, such as low volumetric energy density and lightest element than Helium, account for the difficulty in storing hydrogen. Liquid hydrogen, which is in demand for being used extensively in space travel, has specific challenges; the most common is low storage temperature. Cryogenically, hydrogen can be stored in liquid form where the temperature must be lower than -252.8°C to prevent liquid hydrogen from converting into gaseous form. Subsequently, compression, along with cryogenic cooling, is an advanced developed process for storing hydrogen where the hydrogen is cooled before compressing it. The energy required using this process is equivalent to 9-12% of the energy available for compression and around 30% liquefaction.

To a further extent, hydrogen can also be stored using materials with different processes. Hydride storage, which uses solid materials and liquid, has been extensively used for storing hydrogen. On an industrial scale, underground hydrogen storage can be obtained using salt caverns, abandoned oil and gas wells, or aquifers. Surplus hydrogen can be inserted into the multiple gas network to generate hydrogen-enriched natural gas (HENG), which could be an alternative to underground cavern storage.

Hydrogen Benefits and Energy Security

Hydrogen is generally considered a potential fuel that is on the mark of near-zero greenhouse gas emissions. It can be generated from diverse resources that impulse to produce electric power in a different fuel cell. The emitted elements are only water vapor and warm air, making hydrogen a pure, environmentally friendly fuel. Locally various natural resources such as coal, natural gas, solar energy, wind, etc., can be a prominent source to produce hydrogen, substantially serving as a fuel cell for electric vehicles. Hydrogen fuel strengthens global energy security, preserves petroleum reserves, and transforms energy transportation into a better one. Unlikely emissions from conventional fuels from vehicles are harmful nitrous oxides, hydrocarbons, and unwanted particulates, which is considered a significant pollutant. Still, hydrogen-

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powered fuel vehicles indispensably produce only water and warm air, ultimately making them nature-loving. Consequently, hydrogen carries the potential to circumvent significant challenges to meet net zero emissions globally by 2050.

With the increasing demand for the mobility of compressed hydrogen systems, the capacities and pressure of tube trailers has significantly increased to 1000 kg of hydrogen at 500 bar, the largest. Cryostars' transferable system is very effective as their systems are equipped with a wide range of compressed hydrogen container filling pumps with larger capacities and lower power consumptions than usual compressors.

Impact of COVID-19

The COVID-19 pandemic has led to unprecedented economic crises, affecting the clean hydrogen sector. During the outbreak, a significant lagging has occurred in the adoption and commercial roll-out of pure hydrogen. The momentum of building hydrogen storage infrastructure has slowed as annual installations of energy storage subsequently declined—the structures of the power grid scale fell by around 20%, which created uncertainties around battery safety. The COVID-19 outbreak has impacted several clean hydrogen projects using CCUS technology due to supply chain disruptions, a global economic downturn, and a fall in effective capital investment across energy sectors. Despite various troubles and uncertainties with the growth, there are more rising opportunities to mobilize investments toward clean hydrogen energy storage.

Impact of Russia-Ukraine War

The annexation of Russia on Ukraine has developed sternness in energy security globally, which resembles the center of the geopolitical conversation. The International Renewable Energy Agency (IRENA) has proposed a strategy for the emergence of clean hydrogen as a mainstream source which aims to reevaluate global trade relations, minimize the dependence, and shift the power far away from oil and gas-dominating countries, including Russia and gulf regions. The invasion has soared energy prices globally, which drives 25 countries to commit an investment of around USD 73 billion in fresh lower-cost green hydrogen. A progressive acceleration in the buy to produce clean hydrogen assets has inspired investors across the globe as they are looking at hydrogen as an alternative fuel source.

In October 2022, the cost of pure green hydrogen ranges between USD3.8 to 5.8 per kg, and the impact of war has led to lower prices in a very short time interval. Massive energy importers like Morocco, Chile, and Namibia have already developed strategies

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to become green hydrogen producers and exporters.

Key Players Landscape and Outlook

Prominent companies are heavily investing in sustainability goals to develop technologies for producing green energy. FuelCell Energy Inc., a key player in the green hydrogen industry, offers an environmentally friendly alternative to conventional energy generation. The company's specifications can be admired in different applications such as designing, manufacturing, and operating fuel cell power plants. The company has already implemented operations in over 50 countries, from which only 21 power plants are established in South Korea. It uses trigeneration technology to generate green hydrogen from natural gas or biogas, extending its domain to serve commercial and industrial clients across the globe.

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