**Introduction**

Greeting to all, Welcome to this webinar on Why Hydrogen Now, in this webinar we will be talking about,

Hydrogen, Fuel Cell, Working of Fuel Cell, FCEV, Govt Initiatives. Market oppurtuinities.

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**Why Hydrogen Now**

Hydrogen’s potential to play a key role in a clean, secure and affordable energy future. The recent successes of renewable energy technologies and electric vehicles have shown that policy and technology innovation have the power to build global clean energy industries.

**Reason.**

**Public money is flowing.**

France €7 billion package to build a carbon-free hydrogen industry. Germany issued a similar plan of €9 billion. In July, European Commission said it is looking to increase its production capacity of electrolysers from 250MW today to 40GW by 2030. This show a clear trend towards massive public investments in the sector.

**Refuelling stations.**

Both vehicles and stations are coming at the same time. These ecosystems often include automakers, mobility companies, logistics companies, hydrogen producers, fuel stations, etc. By coming together with both demand and supply at the same time, they can be the key to hydrogen’s development.

**Hydrogen trains**

Germany, Coradia iLint, the world’s first hydrogen-fuelled train, is now expanding to Austria.

**Hydrogen trucks**

Hyundai Motor the Company plans total of 1,600 units by 2025.

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**Discovery of Hydrogen and its Application.**

**1766** Hydrogen was first identified as a distinct element by British scientist Henry Cavendish after he evolved hydrogen gas by reacting zinc metal with hydrochloric acid.

**1785** French scientist Antoine L. Lavoisier successful performed the experiment of Cavendish and named the vital air as oxygen and the inflammable air as hydrogen.

**1800** William Nicholson, First time Hydrogen was produced by electrolysis.

**1900** Ferdinand Von Zeppelin of Germany He invented the first balloon that used hydrogen.

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**1958**, NASA was founded to use hydrogen as a fuel and is the world’s largest liquid hydrogen user.

**1961**, the first rocket by Aerojet Rocketdyne that used liquid hydrogen fuel was launched.

**1981** The first space shuttle was launched, Soviet Union

**1988** The world’s first jet engine aircraft that uses liquid hydrogen as fuel.

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**Development Histories of Fuel Cell Technology**

**1838**, the German/Swiss Christian Friedrich discovered the principle on which fuel cells work

**1899** German Walter Nernst discovered that stabilized zirconia could exhibit conductivity for oxide ions.

**1937** The first solid electrolyte fuel cell was demonstrated by Baur et al. in Switzerland.

**1950,** the first fuel cell that was put into practical use was a PEFC developed by GE in the U. S.

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**1959** British Francis Thomas Bacon developed an AFC (the Bacon Cell), Becon later successfully conducted an experiment on a 5 kW fuel cell.

**1965** The resulting 32-cell 1 kW PEFCs were manufactured through a joint development project with NASA. Two of these units were eventually mounted on the spacecraft Gemini 5.

(**1968–1972**), 32-cell 12 kW AFCs with higher efficiencies were adopted by the Apollo Program.

**1988** German Siemens prototyped a 100 kW-class AFC and mounted it in a submarine.

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**Development of Hydrogen Vehicles**

**1970**, work on hydrogen vehicles was started by BMW.

**1999**, BMW began public roadway tests on 15 vehicles, but in 2009 they would pull out of the hydrogen engine vehicle business.

**2006,** U.S Ford motor company developed and released shuttle buses mounted with V10 hydrogen engines.

**2015,** Toyota designed the world’s first commercial vehicle called the MIRAI and released it on December.

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**Simplified Fuel Cell Diagram**

A fuel cell uses the chemical energy of hydrogen to efficiently produce electricity. If hydrogen is the fuel, the only products are electricity, water, and heat.

Fuel cells work like batteries, but they do not run down or need recharging. They produce electricity and heat as long as fuel (Hydrogen) is supplied. A fuel cell consists of two electrodes—a negative electrode (or anode) and a positive electrode (or cathode)—sandwiched around an electrolyte.

Fuel cells can be used in a wide range of applications, providing power for applications across multiple sectors, including transportation, industrial/commercial/residential buildings, and long-term energy storage for the grid in reversible systems.

Fuel cells have several benefits over conventional combustion-based technologies currently used in many power plants and vehicles. Fuel cells can operate at higher efficiencies than combustion engines and can convert the chemical energy in the fuel directly to electrical energy with efficiencies capable of exceeding 60%. Fuel cells have lower or zero emissions compared to combustion engines. Hydrogen fuel cells emit only water, addressing critical climate challenges as there are no carbon dioxide emissions. There also are no air pollutants that create smog and cause health problems at the point of operation. Fuel cells are quiet during operation.

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**Working of Fuel Cell**

In a hydrogen fuel cell, a catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. The protons migrate through the electrolyte to the cathode, where they unite with oxygen and the electrons to produce water and heat.

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**Phosphoric acid fuel cells (PAFCs)** use liquid phosphoric acid as an electrolyte—the acid is contained in a Teflon-bonded silicon carbide matrix—and porous carbon electrodes containing a platinum catalyst. The electro-chemical reactions that take place in the cell. The PAFC is considered the "first generation" of modern fuel cells. It is one of the most mature cell types and the first to be used commercially. This type of fuel cell is typically used for stationary power generation, but some PAFCs have been used to power large vehicles such as city buses.

**Solid oxide fuel cells (SOFCs)** use a hard, non-porous ceramic compound as the electrolyte. SOFCs are around 60% efficient at converting fuel to electricity. In applications designed to capture and utilize the system's waste heat (co-generation), overall fuel use efficiencies could top 85%. SOFCs operate at very high temperatures—as high as 1,000°C (1,830°F). High-temperature operation removes the need for precious-metal catalyst, thereby reducing cost. It also allows SOFCs to reform fuels internally, which enables the use of a variety of fuels and reduces the cost associated with adding a reformer to the system.

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**Alkaline fuel cells (AFCs)** were one of the first fuel cell technologies developed, and they were the first type widely used in the U.S. space program to produce electrical energy and water on-board spacecraft. These fuel cells use a solution of potassium hydroxide in water as the electrolyte and can use a variety of non-precious metals as a catalyst at the anode and cathode. The high performance of AFCs is due to the rate at which electro-chemical reactions take place in the cell. They have also demonstrated efficiencies above 60% in space applications.

**Molten carbonate fuel cells (MCFCs)** are currently being developed for natural gas and coal-based power plants for electrical utility, industrial, and military applications. MCFCs are high-temperature fuel cells that use an electrolyte composed of a molten carbonate salt mixture suspended in a porous, chemically inert ceramic lithium aluminum oxide matrix. Because they operate at high temperatures of 650°C (roughly 1,200°F), non-precious metals can be used as catalysts at the anode and cathode, reducing costs.

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**Polymer electrolyte membrane (PEM)** fuel cells also called proton exchange membrane fuel cells deliver high power density and offer the advantages of low weight and volume compared with other fuel cells. PEM fuel cells use a solid polymer as an electrolyte and porous carbon electrodes containing a platinum or platinum alloy catalyst. They need only hydrogen, oxygen from the air, and water to operate. They are typically fuelled with pure hydrogen supplied from storage tanks or reformers.

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**Portable fuel cells** are lightweight, long-lasting, portable power sources that prolong the amount of time a device can be used without recharging. In comparison, secondary (rechargeable) batteries have battery charger systems that consist of AC chargers that require an outlet to be charged or DC chargers that will recharge your batteries from other batteries. Rechargeable batteries are not practical for certain portable and military electronic applications because they can be heavy and not meet the power requirements. Some portable fuel cell applications include laptops, cellular phones, power tools, military equipment, battery chargers, unattended sensors, and unmanned aerial and underwater vehicles.

Fuel cells for **stationary applications** have been used commercially for over twenty years. The main difference in these fuel cell systems is the choice of a fuel cell and fuel and the heating and cooling of the stacks. Stationary fuel cells can be used as a primary power source. It is often used to power houses that are not connected to the grid or to provide supplemental power.

Fuel cells can be used for many **transportation applications** including automobiles, buses, utility vehicles, and scooters and bicycles.

**Buses** have successfully demonstrated the use of fuel cells for transportation purposes into the commercial vehicle market. The difference between buses and automobiles are the power requirements, space availability, operating regimen, and refuelling sites. Buses require more power than automobiles and get more wear due to constant stops and starts. Large quantities of hydrogen can also be stored on-board buses easily because of the available area of a bus.

**Utility vehicles** have been a successful early adapter of fuel cell technology because the competing technology for these vehicles is often lead-acid batteries which require maintenance and charging. Demonstrations of fuel cell utility vehicles show that they offer lower operating cost, reduced maintenance, lower downtime, and extended range. Fuel cell–powered utility vehicles can also be operated indoors because there are no emissions. Utility vehicles that can be powered by fuel cells are forklifts, golf carts, lawn maintenance vehicles, airport movers, wheelchairs, unmanned vehicles, boats, small planes, submarines, small military vehicles.

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**Power Control Unit** A mechanism to optimally control both fuel cell stack output under various operational conditions and drive battery charging and discharging.

**Motor** driven by electricity generated by fuel cell stack and supplied by battery.

**Battery** which stores energy recovered from deceleration and assists fuel cell stack output during acceleration.

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**Step 1** Air is taken in.

**Step 2** Oxygen and hydrogen supplied to fuel cell stack.

**Step 3** Electricity and water generated through Chemical reaction.

**Step 4** Electricity supplied to Motor.

**Step 5** Motor is activated and Vehicle moves.

**Step 6** Water emitted outside Vehicle**.**

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**Sarbananda Sonowal, Union Minister for Ports, Shipping and Waterways,**announced thatthe**Ministry of Ports, Shipping and Waterways**would develop andbuild**India’s first indigenous hydrogen-fuelled electric vessels** at**Cochin Shipyard Limited (CSL)**, kicking off the country’s efforts toward**green shipping.** The CSL has partnered with KPIT Technologies Limited and Indian developers in the areas of [hydrogen fuel](https://www.business-standard.com/topic/hydrogen-fuel) cell, power train and Indian Register of Shipping for developing rules and regulation for such vessels.

The integration of **Carbon Capture Utilisation and Storage (CCUS)** units along with gasification, can be explored so that blue hydrogen thus produced is more acceptable. The gasification technologies may be selected based on assessment of the potential for eventual commercial up scaling and keeping the option of biomass co-gasification along with coal subject to availability of biomass in the close vicinity of such gasification units.

Gadkari said under Faster Adoption and Manufacturing of Electric Vehicles (FAME) Phase-II scheme, 2,877 public EV charging stations have been sanctioned in 68 cities and 1,576 EV charging stations across 9 expressways and 16 highways. The number of electric vehicles in the country is **13, 34,385** as on 14-07-2022 and a total of 2,826 public charging stations are operational in the country, as per the Bureau of Energy Efficiency.

[**NHPC**](https://www.business-standard.com/topic/nhpc) signed two MoUs for the development of 'Pilot Green [Hydrogen](https://www.business-standard.com/topic/hydrogen) Technologies' in line with the country's resolve to reduce the carbon footprint in the Power Sector in [Leh](https://www.business-standard.com/topic/leh) and [Kargil](https://www.business-standard.com/topic/kargil" \t "_blank) districts of Union Territory of Ladakh. [NHPC](https://www.business-standard.com/topic/nhpc) will consider the development of a Pilot Green [Hydrogen](https://www.business-standard.com/topic/hydrogen) fuel cell-based Microgrid, including hydrogen production, to meet the power requirement of the NHPC guest house at Nimmo Bazgo Power Station (Leh) within NHPC premises.

S Dasappa, Professor at the Centre for Sustainable Technologies and chairman of the Interdisciplinary Centre for Energy Research at **IISc**, who also led the team, said India uses nearly 50 lakh tonne of hydrogen for various processes in different sectors and the hydrogen market is expected to grow substantially in the coming years. “But most of the hydrogen we currently use comes from fossil fuels through a process called steam methane reforming route. Now, we have found a way to extract green hydrogen from biomass, a renewable energy source,” he said.

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The Union Cabinet approved an Rs 26,058 crore production linked incentive (PLI) scheme for auto, auto-components and drone industries to enhance India's manufacturing capabilities, Union Minister Anurag Thakur said.

The [PLI scheme](https://www.business-standard.com/topic/pli-scheme) will incentivize the emergence of advanced automotive technologies' global supply chain in India.

Incentives worth Rs 26,058 crore will be provided to industry over five years, the minister told reporters after the Cabinet meeting.

It is estimated that over a period of five years, the [PLI scheme](https://www.business-standard.com/topic/pli-scheme) for the automobile and [auto components](https://www.business-standard.com/topic/auto-components) industry will lead to fresh investment of over Rs 42,500 crore, incremental production of over Rs 2.3 lakh crore and will create additional employment opportunities of over 7.5 lakh jobs.

The incentive structure will encourage industry to make fresh investments for the indigenous global supply chain of Advanced Automotive Technology products.

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The [**Union Budget for 2021-22**](https://www.drishtiias.com/loksabha-rajyasabha-discussions/the-big-picture-budget-2021-for-green-energy) has announced a**National Hydrogen Energy Mission (NHM)** that will draw up a road map for using hydrogen as an energy source. The initiative has the potential of transforming transportation.

Key Points

* Focus on generation of hydrogen from green power resources.
* To link India’s growing renewable capacity with the hydrogen economy.
* India's ambitious goal of 175 GW by 2022 got an impetus in the 2021-22 budget which allocated Rs. 1500 crore for renewable energy development and NHM.
* The usage of hydrogen will not only help India in achieving its emission goals under the [Paris Agreement](https://www.drishtiias.com/daily-updates/daily-news-analysis/five-years-of-paris-climate-accord), but will also reduce import dependency on fossil fuels.

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Growing demand for long-range zero emissions commuting coupled with governments supporting low emission vehicles through subsidies & tax rebates has led automakers to adopt Fuel Cell Electric Vehicles (FCEVs). This phenomenon has led to the growth of the automotive fuel cell market.

According to the new market research report “Automotive Fuel Cell Market by Component (Fuel Processor, Fuel Cell Stack, Power Conditioner, Air Compressor, Humidifier), Power Output, Hydrogen Fuel Stations, Vehicle Type (Passenger car, LCV, Truck, Bus), Operating Miles, Region - Global Forecast 2028”, published by MarketsandMarkets, the market size is projected to grow from 20,168 units in 2021 to reach 596,255 units by 2028, at a CAGR of 62.2%.