

GREEN HYDROGEN: PROMISING FUEL FOR FUTURE

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ABSTRACT

*Green hydrogen is a term now-a-days is being used especially after announcement of National Hydrogen Energy Mission (NHEM). While announcing the motive of this mission it was committed that it would be holding Green Hydrogen auctions. After announcing this mission all the companies engaged in the production of energy are planning and somewhat started to produce green hydrogen as fuel. The process used in the production of green hydrogen is called as **Electrolysis**. Under this process electric current is used to separate the hydrogen from oxygen in water. When the electricity used in this process is renewable source (wind or solar) then it produces green hydrogen. The energy obtained this way does not emit carbon dioxide into the atmosphere. The whole world is anxious about the global warming due to use of fossil fuels. Now the world is seeing '**great white hope**' in **Green Hydrogen**. Due to great importance and big expectations from green hydrogen, an attempt has been made to write a paper on this burning topic. The efforts have been taken to explain the term 'green hydrogen', how it is obtained, types of hydrogen as fuel, what are the pro and cons of it, what is NHEM, which companies are engaged in the production of green hydrogen, etc.*

Keywords: Grey Hydrogen, Blue Hydrogen, Green Hydrogen, Global Warming, Electrolysis.

Introduction

Countries around the world are discussing a lot on green hydrogen as an alternative of traditional fuel. Green hydrogen is obtained by electrolysis of water. The most beauty of this method is that this electrolysis process entirely powered by renewable energy (like wind or solar). The process of producing energy this way generates no polluting emissions into the atmosphere, so this is the most vital thing that it is environmentally sustainable way of producing energy. In addition, green hydrogen can also be termed as clean energy source as its generation emits water vapour and leaves no residue in the air unlike coal and oil.

Here a question arises that why green hydrogen is called as 'green'? Actually while producing hydrogen with electrolysis process, water is split into hydrogen and oxygen with the use of electricity generated from the source of renewable energy. So while producing hydrogen as fuel element we find significantly low carbon emissions then other kind of fuel generation. Moreover, hydrogen is a naturally occurring gas and most abundantly available in the universe (**it is around 75% of matter**). Its use is more environmentally friendly than fossil fuels, as it emits only water when it is burnt. It is said that whenever we talk about green hydrogen our intention is to say about the fuel which is obtained without generating pollutant emissions. Green Hydrogen, **a fuel of future**, now-a-days is being presented as the key energy vector for protection the planet from global warming. It can also be yard stick in fulfilling the commitments made for 2050 to fight against climate changes.

According to the International Energy Agency (IEA) hydrogen could play an important role in our clean energy future. It is also important to mention here that the use of green hydrogen in untouched area like transport, buildings and energy production can make real contribution to the energy transition. India is joining in the global race of developing the green hydrogen production. After declaration of India's green hydrogen policy various private and public sector companies have announced about the setting of project of producing green hydrogen.

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Types of Hydrogen as a Fuel

The production methods of hydrogen resulted into a colour nomenclature, according to this colour scale it can be classified in three types, i.e. **Grey Hydrogen**, **Blue Hydrogen** and **Green Hydrogen**.

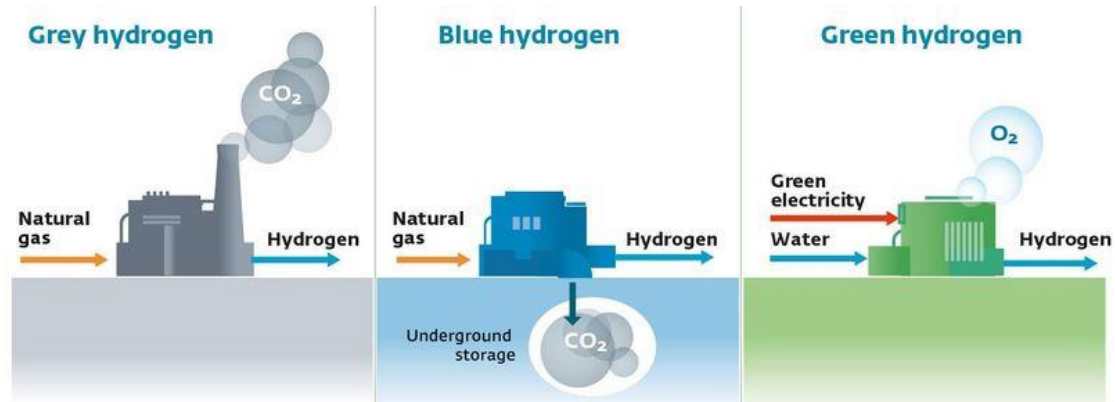


Figure: Depiction of grey, blue and green hydrogen production

Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fenergyeducation.ca%2Fencyclopedia%2Ftypes_of_hydrogen_fuel&psig=AOvVaw3275ooNRtTPsssC3gyPv7&ust=1673890109804000&source=images&cd=vfe&ved=0CBiQ3YkBahcKEwjI98_djMr8AhUAAAAAHQAAAAQEA

- **Grey Hydrogen**

Grey Hydrogen is obtained using fossil fuels such as natural gas or methane or coal through a process called "steam reforming". Presently it is being commonly used and is the cheapest hydrogen to produce but this process emits a large amount of carbon dioxide CO₂. Most of the hydrogen produced now-a-days is grey hydrogen (today it accounts approximately 95% of total hydrogen produced in the world) and commonly used in chemical industries basically to produce fertilizer and for refining oil. While producing hydrogen if carbon dioxide is released in atmosphere, then it refers to grey hydrogen. According to International Energy Agency (IEA) production of hydrogen released around 830 million tonnes of carbon dioxide per year, which is equal to the CO₂ emissions released by UK and Indonesia.

- **Blue Hydrogen**

Blue hydrogen is obtained from fossil fuels using an energy-intensive process which emits a lot of carbon dioxide-CO₂. Blue hydrogen is quite similar to grey hydrogen, but during its production process the carbon dioxide is captured and stored instead of releasing it into atmosphere. Blue hydrogen is less polluting than grey hydrogen as it is only capable of reducing emissions from its production process, but not eliminating them completely. It is important to mention here that when blue hydrogen is burnt or converted into energy it does not produce carbon emissions, but while producing it the use of main component methane (CH₄) becomes potent of greenhouse gas emissions. So presently it is not possible to produce clean blue hydrogen for commercial purposes. While comparing blue hydrogen with grey hydrogen it can be said that blue hydrogen is a cleaner alternative to grey hydrogen, but is expensive due to use of carbon capture technology.

- **Green Hydrogen**

As mentioned above green hydrogen is produced by electrolysis of water. The most important thing is that the power used in the production of green hydrogen is entirely renewable energy (i.e. **wind or solar**) which does not emit any kind of pollutant emissions. Green hydrogen is considered as the cleanest and most sustainable hydrogen since its by-products are just water and water vapour. Green hydrogen has become so important now-a-days that it is considered as **fuel of future**. It is that kind of fuel on which the whole world is seeing as the key energy vector for reducing emissions and preparing for fighting against **climate change**. All sources used by renewable energy industry are not necessarily green. If some organic material burns while producing power that may be renewable but that may not be green because of emitting CO₂ during burning process.

Green energy sources are usually not exhaustive as they naturally replenishable, these sources are available abundantly and need not to mine or drill which again avoid damaging eco system. The main sources of green energy are solar power, wind power, tidal power (ocean energy) and hydroelectric

power. The main advantages of these energy resources are that these are eco-friendly and are not harmful to the environment through factors such as releasing greenhouse gases into the atmosphere. Green energy may become the base for stable energy prices as these sources are easily available locally and there are no chances of being affected by geopolitical crisis. Job creation in developing the facilities is also another economic benefit of green hydrogen to the society. Green energy can also prove as a low-cost solution for the energy requirements of the world. Further, easily availability of green energy will be advantageous especially for developing countries.

- **Other Colours**

In the energy industry, other colours may also be identified to make difference between the various types of hydrogen depending upon the use of sources for production of energy. We find the rainbow of hydrogen colours depending upon the use of different types of technology to produce each. Though hydrogen gas is an invisible and there is no visible difference among different types of hydrogen. However, depending on the type of production techniques, different colours are assigned to the hydrogen. It is also important to mention here that there is no universal acceptable colourful description of hydrogen and this colour distinction may vary over the time period or/and in different countries. Although grey, blue and green are very common colours, but **black, brown, red, pink, yellow, turquoise and white** also exists.

Black Hydrogen: **Bituminous coal** is used to produce black hydrogen. Bituminous coal or black coal is a type of coal which contains a tar-like substance called bitumen or asphalt. Its coloration can be black or sometimes dark brown;

- **Brown Hydrogen:** For the production of brown hydrogen **lignite** (brown coal) is used. Lignite is also referred to as brown coal or soft coal and contains relatively low heat content.
- **Red Hydrogen:** For red hydrogen **biomass** is used. Biomass is renewable source formed from organic material that comes from plants and animals, e.g. wood, wood residues, energy crops, organic waste from industry and households, etc.
- **Pink Hydrogen:** Pink hydrogen is produced through electrolysis process powered by **nuclear energy**. Nuclear power is the use of nuclear reactions like-nuclear fission, nuclear decay and nuclear fusion, uranium is used generally used as base material for this purpose.
- **Yellow Hydrogen:** Yellow hydrogen is produced through electrolysis process powered by **solar energy**. But some time it also refers to as powered by a mix of energy sources e.g. mix of renewable and fossil power flowing through electric grid.
- **Turquoise Hydrogen:** Turquoise hydrogen is produced through a process called methane pyrolysis. Methane pyrolysis is a process technology under which natural gas or biomethane is separated into the component's hydrogen and solid carbons. For this purpose, when renewable energy sources are used then no greenhouse gas emissions are found.
- **White Hydrogen:** White hydrogen is the natural form of H₂ and found naturally in underground deposits releasing by fracking process. Fracking process is a method of extracting petroleum or natural gas from deep in the earth by injecting water, chemicals and sand.

National Hydrogen Energy Mission (NHEM)

In 2021, on the eve of Independence Day the Prime Minister Narendra Modi announced the National Hydrogen Energy Mission (NHEM) with the aim of cutting down carbon emissions, enhancing the use of renewable sources of energy and becoming less dependency on import of petroleum. In this respect the government also declared that this mission would be holding Green Hydrogen auctions. On 4th January 2023 the Union Cabinet sanctioned initial outlay of Rs 19,744 Crore for green hydrogen mission that aims to make India '**global green hydrogen hub**' for the production of green hydrogen. The Ministry of Renewable Energy (MNRE) has been authorised to implement and formulate the scheme for using hydrogen as an energy source.

Hydrogen is the most abundantly available element on the earth and this mission aims to capitalize all the properties of this element. Being a clean source of energy hydrogen has the potentiality to transform the transport sector as well as other industries. It is also expected from the mission to fulfill the growing demand of renewable energy with the hydrogen economy. This mission can prove to be helpful in serving dual purpose of achieving India's emission commitments (as per Paris Agreement) and reducing the dependency on import of fossil fuels.

National Hydrogen Energy Mission – Need for the Mission

It is said that the '**necessity is the mother of invention**'. The whole world is facing problem of energy resources as well as consequential environmental issues. India is also sailing on the same boat. There are various factors due to that, the hydrogen is being promoted and the Government of India is also taking big initiations in this respect.

- **External Factors:** In Asia-Pacific sub-continent Japan and South Korea are playing on front foot as regards to use and production of hydrogen energy. Japan initiated the Basic Hydrogen Strategy in 2017 and aims to set it by 2030. This strategy includes the establishment of international supply chain. South Korea is also establishing hydrogen projects under the Hydrogen Economy Development and Safe Management of Hydrogen Act, 2020.
- **Internal Factors:** Owing to its favourable geographic conditions and abundantly availability of natural elements India has big opportunities in the production of green hydrogen. Government of India is also committed to fulfil its commitment made for 2050 to fight against climate changes. Government aims to reduce its dependency on the coal and petrol. The use of green hydrogen can be most benefitted to the transportation, iron & steel and chemical industries.

Advantages of Hydrogen Energy

As compared to traditional sources of energy hydrogen energy put forward many advantages (mentioned below) which are indicator of its superiority.

- It is a renewable source of energy and available in abundance.
- It generates energy that produces no greenhouse gas emissions so beneficial for improving public.
- It reduces the dependency on imported fuels.
- It will be able to create more jobs especially for local community and other economic benefits.
- It is more powerful than any other kind of fossil fuels.
- It may prove stable energy prices.
- It provides more reliability and resilience.
- More or less, it is inexhaustible.
- It is light in weight and can be stored in tank so useful for automobiles.
- It can be refilled very fast.

Disadvantages of Hydrogen Energy

Though hydrogen energy is much useful in various aspects, still some disadvantages are seen in using it, these can be listed as follows:

- Hydrogen is a highly inflammable and explosive element as it is very dense in energy, so it is risky and dangerous fuel.
- It is a gas which is handled difficultly.
- It is difficult also to transport from one place to another place, being a lighter substance.
- As compared to electric power for cars hydrogen is less advantageous.
- If it is "grey", then it produces more carbon.
- Hydrogen energy is comparatively more expensive than traditional sources, which makes it a slow process of adoption.

Superiority of Hydrogen Over Conventional Source of Energy

Being considering all pre and cons of hydrogen energy, it can be concluded that the hydrogen engine still remains much more efficient than traditional (Petrol/Diesel) engine. Diesel engine provides lesser financial advantages over hydrogen. Environmental benefits of hydrogen would offset its higher production cost.

Companies' Involved in the Production of Green Hydrogen

As earlier mentioned, the Government of India announced National Hydrogen Energy Mission (NHEM) in Union Budget 2021-22 with the aim to draw up a road map for using green hydrogen as energy source. On 4th January 2023 an initial outlay of Rs 17,490 Crore has been sanctioned for its production and manufacturing of electrolyzers. But it is yet to announce that how these funds are to be utilized.

Many private sectors have already, way back in 2021, initiated to build pitches to run fast on green hydrogen after announcement of India's Mission 'NHEM'. The corporate sector initiated in this respect may be listed as follows:

- **Adani Group:** On 14th June 2022 Adani New Industries Ltd (ANIL), a subsidiary company of adani group, announced that a partnership has been entertained with France's Total Energies SE., which aims to invest \$50 billion during a period of 10 years in India and aims to establish the capacity to produce green hydrogen of 1 million tonnes per annum before 2030.
- **Reliance Industries Ltd (RIL):** On 29th August 2022 the chairman of Reliance Industries announced that the company will be able to replace the production of grey energy to Green energy by 2025. The company also claims to reduce production cost of green hydrogen to under \$1/kg by 2030. The company is also talking with heavy vehicle manufacturers for the development and supply chain of hydrogen-powered engines. The company is planning to spend \$75 billion on clean energy projects over the next 15 years.
- **Bharat Petroleum Corporation Ltd (BPCL):** The company is going to set up a plant of 5 MW electrolyser system to produce green hydrogen. The company has also signed a MOU with Government of Odisha for setting-up a plant for the production of renewable energy and green energy plant. For the production of green hydrogen, the company has made collaboration with Bhabha Atomic Research Centre (BARC)
- **GAIL India Ltd:** In the month of May 2022 the state-owned Gail (India) Ltd announced that it will install one of the largest Proton Exchange Membrane (PEM) Electrolyser at Guna in Madhya Pradesh to produce green hydrogen by 2023. The project is designed to produce 4.3 Metric Tonnes of hydrogen energy per day. The hydrogen produced by GAIL will be sold to fertiliser units which are mandatory required to use hydrogen as fuel.
- **NTPC Ltd:** India's largest energy producing company, NTPC, aims to use a capacity of 5 GW to produce green hydrogen and ammonia out of its 60 GW green portfolio by 2032. According to a press release on 15th Dec.2021 by NTPC "NTPC, India's largest integrated energy company has awarded project of 'Standalone Fuel-Cell based Micro-grid with hydrogen production using electrolyser' at NTPC Simhadri (Andhra Pradesh). This will be India's first Green Hydrogen based Energy Storage Project and one of world's largest".
- **Indian Oil Corporation Ltd (IOCL):** While rereleasing press note by IOCL it was declared that:
 - Three companies IOCL, L&T, and ReNew to form Joint Venture for development of Green Hydrogen Business and to hold equal stake in proposed Green Hydrogen Joint Venture.
 - The Green Hydrogen JV aims to develop, execute & own green hydrogen assets in India.
 - Under Aatmanirbhar Bharat Mission, both JVs to enable India's transition from a grey hydrogen economy to a greener one.

IOCL has planned to replace at least one tenth of its production of current fossil-fuel-based hydrogen with green hydrogen as a part of decarbonisation drive. As mentioned in the PSU's annual report, the company is targeting 5% of hydrogen produced as green hydrogen by 2027-28 and 10% by 2029-30.

- **ONGC Ltd:** As mentioned on the website of the company a MOU has been signed with M/s Greenko ZeroC Private Limited (Greenko), to jointly pursue opportunities in Renewables, Green Hydrogen, Green Ammonia and other derivatives of green hydrogen. This MoU is in line with the National Hydrogen Mission launched by Hon'ble Prime Minister in making India a global green hydrogen hub. The activities envisaged under this MoU will contribute towards India's target of producing of 5 million tonnes of green hydrogen per annum by 2030.
- **Hindustan Petroleum Corporation Ltd (HPCL):** Addressing investors during a post-quarterly earnings conference call, the Chairman and Managing Director (CMD) M K Surana of State-run Hindustan Petroleum Corporation Ltd (HPCL) mentioned that the company will be putting up a 370-tonne per annum capacity green Hydrogen plant in Vizag refinery, soon. He again added "Our R&D centre in Bengaluru, has been using only green Hydrogen produced from electrolyser using renewable energy, for the last one year."
- **Larsen & Toubro LTD (L&T):** Larsen & Toubro (L&T), an Indian multinational engaged in EPC Projects, Hi-Tech Manufacturing and Services, commissioned a green hydrogen plant at its AM Naik Heavy Engineering Complex in Hazira, Gujarat in August 2022. The plant is producing 45

Kg of Green Hydrogen daily for the purpose of captive consumption. The Green Hydrogen Plant has been designed for an electrolyser capacity of 800 KW and will be powered by a rooftop solar plant and Battery Energy Storage System (BESS).

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