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Hydrogen: The Future's Fuel

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Abstract

The exploitation of fossil fuels at a tremendous scale, especially after the industrial revolution in the 18th century, has instigated damage to the environment. The usage of fossil-based fuels results in an excess accumulation of greenhouse gases (GHGs), i.e., mainly CH_4 and CO_2, in the atmosphere. This is the reason for decreasedair quality, increased global warming, and disturbed seasonal variations in many world regions. The usage of Hydrogen (H_2) as a fuel is a promising alternative to fossil fuels due to its high calorific value, clean-burning characteristics, and abundance availability from different feedstocks. H_2 can be a game-changer in the fuel industry especially if utilized commercially in transportation sector giving net-zero carbon emission. The recent research is going on the techno-economic feasibility of H_2 production, and recently an Indian Oil & Gas conglomerate Reliance Industries pledged to produce blue H_2 at $1.2-$1.5 / Kg. The concept of the H_2 economy is encouraging and supports the pledges of the Paris Agreement. The different H_2 production techniques, along with the corresponding color spectrum, have been discussed in this article. Finally, the prospects and advantages of green H_2 have been discussed over its other color spectrum.

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Keywords

Environment, Fossil Fuels, Greenhouse Gases, Global Warming, Hydrogen Fuel.

Short Communication

'Necessity is the mother of invention' there is no doubt in this proverb by Plato. However, human is greedy, and due to this thirst to achieve bigger, the necessity becomes the sole objective of making profits. The industrial revolution in the 18th century began and was welcomed by different nations of the world, which helped attain a better standard of living. However, the development becomes a curse due to its sustainable nature. So is the case with the over exploitation of fossil fuels. The fossil fuel is formed in millions of years under the earth's crust, whereas it has been exploited over 75% in only two centuries[1–3] This tremendous usage of fossil fuels in a brief period resulted in the accumulation of GHGs in the earth's atmosphere.[2,3] This extreme

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accumulation of GHGs in the atmosphere at such a pace resulted in the intense change in the climate all over the world.[4,5] The deterioration in air quality, the rising global temperature, droughts, flooding are some of the visible consequences of present scenarios.[6,7] The Paris Agreement held in 2015 aimed to control the global temperatures and their devastating consequences, which, however, seems unattainable to date. A promising alternative is needed (i.e., both in terms of techno-economic feasibility and carbon free), which could act as a game-changer in the energy sector, and to control the destructive results caused by the usage of fossil fuels.[8] H_2 usage can help in significant control of air quality if used in transportation sector by reducing the air pollution by 80%. Currently H_2 produced from polymer electrolyte membrane (PEM) electrolyzers cost in the range of ~$5-$6/Kg, which is the most economic price as per the reports of DOE, USA[9] Further, the Indian Oil and Gas conglomerate Reliance industry pledged to deliver the economic blue H_2 in the market at the rate of $1.2-$1.5/Kg by investing a sum of $4bn in H_2 energy sector. About 87% of total H_2 is produced globally in 2020 which constitute around 1% of world's energy consumption, which is expected to increase to 4% in 2030 and 13% by 2050, as per the reports of IEA.[9]

The H_2 is one such potential alternative fuel that could replace the fossil fuels from the market in the future[10,11] The H_2 has several added benefits over fossil-based fuels, which encourages researchers to commercialize it globally. The H_2 on combustion gives out only water, which makes it clean fuel. Further, it has a high calorific value when compared to fossil-based fuel and an abundance of cheap feedstock in the form of water if economic limitations are resolved[12-15] Fossil-based fuels can be utilized for H_2 production via reforming techniques. Also, due to increased emphasis on biodiesel production in the future, its waste bi-product, i.e., glycerol[13] can be used as a rich feedstock for H_2 production, supporting the concept of waste to energy and circular economy.[16] The H_2 produced, however, is of utmost benefit if it is green hydrogen to support sustainable development.[17] The H_2 spectrum based on the process adopted for its production and the source of energy used has been summarized in Table 1.

Table 1: The hydrogen fuel spectrum based on the adopted technique and energy source used for its production.

S. No.	Class of H_2 Fuel	Production method	Major Findings
1.	Green	Electrolysis of water	The process is mainly solar, or wind powered.
2.	Blue	Splitting natural gas into H_2 and CO_2 via reforming processes	CO_2 produced with H_2 during the refor -ming process is captured and stored.
3.	Grey	H_2 is produced via fossil fuels like natural gas by gas reforming processes	CO_2 generated during the process is not captured and is released free into the atmosphere.
4.	Pink	Electrolysis of water	The process is mainly powered by nuclear energy.
5.	Turquoise	Pyrolysis of CH_4 is done to produce H_2	The carbon produced is stored in the solid form.
6.	Black or Brown	Gasification techniques	Black (bituminous) or brown (lignite) coal is used for gasification. This is most damaging to the environment.
7.	White	Naturally occurring H_2 present underground in geological formations	These H_2 deposits are formed via fracking. Presently they cannot be exploited because of technical limitations.

Around 90% of the world's H_2 produced is grey in nature and produced from reforming fossil-based fuels.[18–22] The green H_2 is beneficial for replacing fossil-based fuels and will help eliminate the carbon footprints.[23,24] Hence, it can be concluded that the various colors of H_2 production will vanish with time, whereas others will shine. Therefore, it may be summarized that the future of the H_2 economy lies in the green, blue, and turquoise H_2. This is due to the carbon capture scheme and the corresponding clean H_2 production methodology. This predictive analysis is supported by the latest multibillion-dollar projects adopted by different private sectors and governments. The USA, U.K., Arabian Peninsula, Russia, and China are thriving very hard to be the largest stakeholder in the world of the H_2 economy.

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Conflict of Interest

The authors do not have any conflict of interest.

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