White Hydrogen The Ultimate Source of Clean Energy

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THE Paris Climate Agreement was adopted by 196 parties at the UN Climate Change Conference (COP 21) in 2015 in order to limit the increase in global temperature to well below 2°C as compared to the pre-industrial revolution era while pursuing efforts to limit it to 1.5°C, has set a goal at reducing the emission of the greenhouse gas carbon dioxide by 45% by 2030 and to reach net zero by 2050 (However, India has set the target of achieving it by 2070). Therefore, there is currently a huge global rush to change from carbon-based fossil fuels to alternative renewable energy sources, of which hydrogen has proved attractive.

Although it is present on the earth in huge quantities as compounds like water and hydrocarbons, the atmosphere contains it in negligible quantity (0.00005%) in the free state. Therefore, to produce it commercially and in an eco-friendly manner, scientists are adopting and developing various technologies. As a result, it has now become possible to produce around 95 Mt of hydrogen globally every year that can be used as fuel. Again, an aim has been set to increase it to 150 Mt by 2030, 216 Mt by 2035, and 430 Mt by 2050 (350% increase), whose end use in various sectors, according to the International Energy Agency (IEA), is given in Table 1.

Assigning Colours to Hydrogen

The British scientist Henry Cavendish discovered in 1766 that hydrogen is a colourless and odourless gas with no taste. However, depending on the production source, it has been assigned different colours, such as brown, black, grey, pink, and green. Most of the gas that is used as an industrial chemical is called *brown*. It is made through the gasification of coal or lignite. So, the very process of its generation is the most damaging to the environment. Similar is the case with *black* hydrogen. The only difference is that black coal is used for its production, while brown hydrogen lignite (brown coal) is the starting material.

Hydrogen is called grey if it is made through steam methane reformation, which typically uses natural gas as the feedstock. The process is not quite carbon-friendly. However, a relatively cleaner option is *blue* hydrogen, which is produced by steam methane reformation, but the emissions are curtailed by using carbon capture and storage. It can roughly halve the amount of carbon produced but is still far from emission-free. On the other hand, *pink* hydrogen is generated through electrolysis powered by nuclear energy (It is also referred to as purple hydrogen or red hydrogen). However, it is costly and can cause various problems associated with nuclear reactors. A more recent addition to the list is *turquoise* hydrogen. It is produced by methane pyrolysis, and the other product is solid carbon, which can be permanently stored or used for industrial processes such as steel making or battery manufacturing. This thermal process can be powered by renewable energy, but it is yet to be developed. Therefore, at present, more attention has been given to the production of green hydrogen produced by the electrolysis of water using solar energy, which is supposed to be quite eco-friendly and is expected to be generated on an industrial scale in the near future.

Green Hydrogen

Electrolysis of water is now considered one of the main sources of hydrogen that can be used as fuel. Certain countries already use it for cooking, heating houses, and transporting goods. However, the objective of decarbonising heavy industries can be met only by the use of green hydrogen, which is generated by hydrolysing water with renewable energy sources such as solar or hydro. Technologies are already available, but further development is still needed to make the fuel completely emission-free and cost-effective.

Such an electrolyser currently has only 60 to 80% efficiency, and establishing it is quite costly. According to a report by the International Energy Agency, the cost of generating 1 kilo of green hydrogen is now \$3.80 to \$7.50 compared to \$0.90 to \$3.20 for producing the same amount of hydrogen by steam methane reformation process.

Therefore, it may take quite some time for green hydrogen to be commercially viable. However, it is hoped that with the improvement of technology, its production efficiency may increase by 5 to 6 fold by the end of the decade, making its price competitive.

White Hydrogen

In the meantime, a new perspective has been opened to produce almost completely pollution-free hydrogen, namely *white hydrogen* or *gold hydrogen*, which is stored in huge quantities under the earth's crust in a free state. The story of its discovery goes back to 1987 when a team of well-diggers dug a bore well near the village of Bourakebougou in Mali.

Table 1: End use of hydrogen fuel in various fields as projected by the IEA (Mt/per annum)

End-use	2022	2030	2035	2050
Refining	42	35	26	10
Industry	53	71	92	139
Transport	--	16	40	193
Power generation	--	22	48	74
Others	--	6	10	14
Total	95	150	216	430