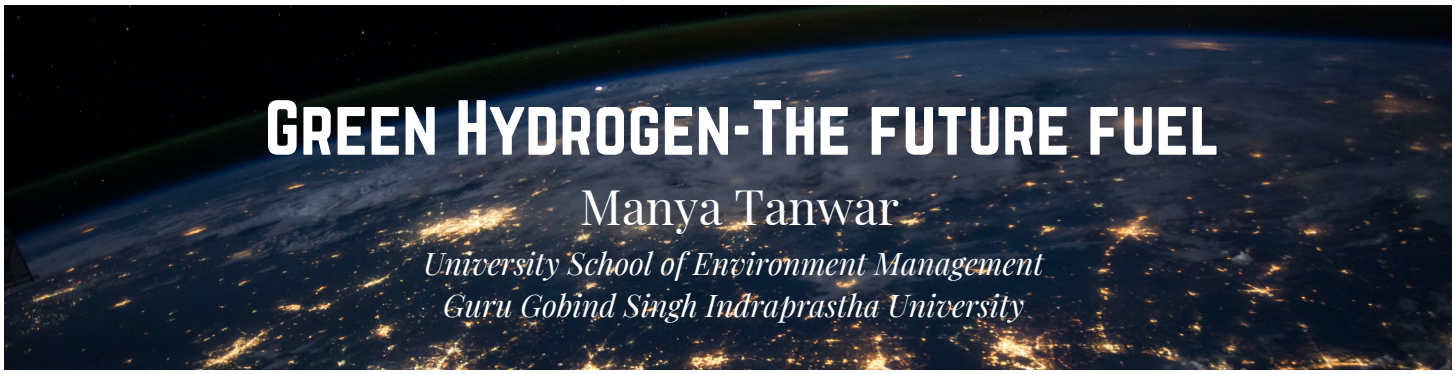

Green Hydrogen-The future fuel

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The increasing ambition of climate targets creates a major role for hydrogen especially in achieving carbon-neutrality in sectors presently difficult to decarbonise. For hydrogen to have a role in future low-carbon energy systems, it is necessary to demonstrate that it has sufficiently low carbon emissions. It is well known that renewables will help us to achieve carbon neutrality, a lot of work has been done on harnessing solar and wind energy with their merits and de merits. The majority of the fuels used even today are coal, oil, natural gas, and petroleum. It has been fairly understood that fossil fuels release a very last amount of carbon in the environment still majority of the energy demands are still met with them. From the pre-existing data it is clear that on combustion coal releases carbon dioxide, carbon monoxide, Sox, NOx, fly ash but still globally we see that coal, followed by gas, is the largest source of electricity production. Petroleum is the most widely used fuel (but used only 1% in the electricity production). When fossil fuels are burned, they release nitrogen oxides into the atmosphere, which contribute to the formation of smog and acid rain. Burning of natural gas produces nitrogen oxides and carbon dioxide, but in lower quantities than burning coal or oil. When coal is burned, carbon dioxide, sulphur dioxide, nitrogen oxides and mercury compounds are released. Burning oil at power plants produces nitrogen oxides, sulphur dioxide, carbon dioxide, methane and mercury compounds. Realising the current scenario, it has become a necessity to shift to Renewable sources and majorly to the renewable sources that would help us achieve a zero-carbon economy as we wish to till 2070.

Prime Minister Modi made the pledge, the first time India has set a net zero target, at the Glasgow summit. So, the questions that come to our minds -are the currently employed hydrogen production methods really producing green hydrogen? Why green hydrogen is not yet common in use in different sectors of India and other countries? Can it be really regarded as the Future Fuel or it is far from reality? Some ways to produce hydrogen are:

1. Hydrogen production by reforming hydrocarbons and methanol. It is the most economic technology now a days. High temperature of 1200K and high pressure of 20-30 atmospheres is required where natural gas reacts with steam over a Nickel catalyst to produce Hydrogen and Carbon monoxide. Also, natural gas contains Sulphur impurities. So clearly the method is not green or the hydrogen produced in not Green.

2. Thermo Chemical methods. Here high temperature of 2500 degree Celsius is required along with chemicals.

a.) Westinghouse Electrochemical Thermal S Cycle. Wherein electrochemical reaction and thermolytic method are applied. By the thermolysis of Sulphuric acid water, oxygen and sulphur dioxide are also produced which is a gaseous air pollutant. Also, in the electrolysis of water SO2 is used to produce Hydrogen. So, we conclude that Green Hydrogen is not produced from this method.

b.) Bromine S cycle and

c.) Iodine S cycle also employ the same applications as the Westinghouse Electrochemical Thermal Cycle. So, none of the methods described so far produce Green Hydrogen.

3. Electrolysis of Water- splitting of water into hydrogen and oxygen. Diaphragms made up Asbestos are placed between the electrodes which are dipped in water mixed with KOH. When a voltage is given, energy is released at the anode and at the cathode hydrogen is produced. The method has two types of electrode arrangement. Tank type Electrolyser(a.) and Filter press electrolyser(b.). Here lies our answer and Electrolysis is the perfect match as it is a cleaner way to produce hydrogen. National Hydrogen Mission has been launched by the Government of India on 15 August 2021. As a part of the policy, Government of India also launched PNG (Piped National Gas) which is a fossil fuel although releasing very less carbon dioxide. Attention has been put on mixing both of them then industry bump up is predicted with negligible number of emissions. 2021-2024 has been categorized as the Pilot Phase and after 2024 mass adoption and commercialization of Green Hydrogen is targeted. The focus to use renewable energy like wind and solar energy to produce electricity that would be used in the electrolysis to produce hydrogen. It is apt to say here that if the electricity is coming from non-renewables to produce hydrogen, then the hydrogen produced cannot be regarded as Green Hydrogen.

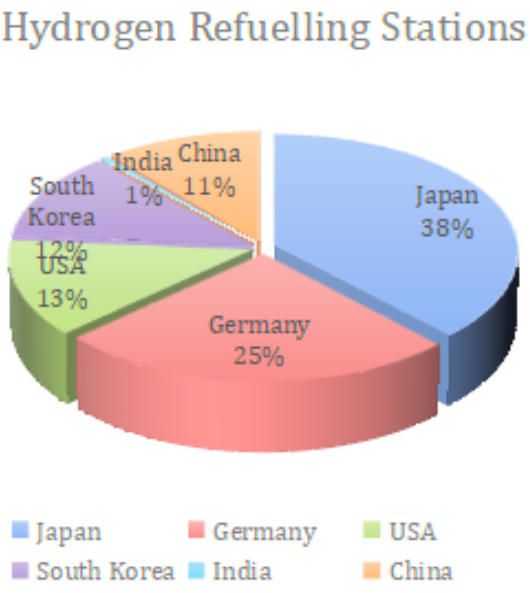
Green Hydrogen Cars- Present scenario in India and Globally

Let us understand this by realizing the facts that to hit a market, the following five criteria have to be fulfilled by using a chart-

1. Price- Based on my research from the existing sources I found out that there are currently 3 Green Hydrogen cars in the world namely Toyota Mirai, Hyundai Nexo, Honda Clarity. None of these is for sale in India but can be imported. Talking about the price Toyota Mirai costs 37L for the cheapest model, Hyundai Nexo is for 65L and Honda Clarity for 44L.So, it's clear that to even think about the cars for the common people is far off from the reality.

2. Fuel Availability- From the existing source I found that by December 2020, 31,225 Green Hydrogen cars were sold, South Korea being on the top (10041 cars), followed by America (9134), China (5546), Japan (4100). The fuel stations are highest in Japan (134 stations), Germany (90), USA (46), South Korea (43), China (39) (The Economic Times). Talking about India, there are 2 Hydrogen fuel stations – Indian Oil RND Station in Faridabad and National Institute for Solar Energy in Gurugram. Also, to fill one Hydrogen car approximately Rs. 6,000 is spent, which is very expensive (The green hydrogen portal).

Let us understand the Hydrogen refuelling stations in the world currently using self-made pie chart-



1. Performance- It is found that Hyundai Mirai, takes 9.1 seconds to reach the speed 60Km from 0Km.The top speed of the Hydrogen cars is estimated to be 106 miles per hour which is not to bad still not up to the mark as compared to other cars.

2. Environmentally Friendly- It is also important to access the energy wastage to produce a fuel also. For instance, 100Watts of electricity is produced by wind energy that is used to produce Green Hydrogen by hydrolysis. 25%of the energy is wasted to cool it, 10% electricity is further wasted to fuel the station and 40% is wasted in the car. Out of 100W electricity 38W electricity is used and 62% energy is wasted (The Economic Times). Comparing to Electric Cars only 20% of the energy is wasted.

3. Competition- Presently Green Hydrogen cars are yet to become a reality in terms of Competition with other cars.

4. A very impressive use of Green Hydrogen has been seen in the 2020 Tokyo Olympics and Para Olympics, wherein the entire Olympics village was run on Green Hydrogen.

A hydrogen economy has long been promoted as a ground-breaking aspect of a low-carbon future. After going through a lot of papers I realized that a lot of work is being done in this direction but a lot is yet to be achieved. Currently shifting to green hydrogen by the developing countries is not yet economical due to a lot of challenges that we explored in the paper- from the green hydrogen research to be underfunded to green hydrogen production being costly.

It also became evident that green hydrogen cars are not and will not become common in India currently due to a lot of issues from the cars being very expensive to the inappropriate number of hydrogen fuelling stations. There are a lot of hurdles in it be adopted immediately. A lot of work is yet to be done. Green hydrogen is increasingly seen as a way of bringing offshore wind to shore and relieving pressure on an already overloaded onshore grid.

One of the biggest questions is whether enough green hydrogen can be ready fast enough to make a difference to climate change. Industrialists and environmentalists believe that- “we live within the constraint of carbon budgets. Electrolysers are not microchips. Of course, costs will go down significantly, but will they go down fast enough to meet the Paris climate goals?” As demand for hydrogen grows and green hydrogen gets cheaper, it will supplement and replace this fossil-based blue hydrogen. Japan, who invested in hydrogen long before climate neutrality was on the agenda, is working with its main supplier, Australia, to transition from grey to blue to green. Green hydrogen will ultimately be cheaper than grey hydrogen because of very cheap power from wind and solar. That is the game-changer. The fuel can be a game-changer for the energy security of India, which imports 85% of its oil and 53% of gas requirements. So, it can be concluded that if proper work and attention is given to green hydrogen then definitely the world would be shifting from running the economy majorly on fossil fuels to renewables where green hydrogen would definitely be at the top, ultimately reducing carbon emissions and achieving carbon neutrality in the near future.