Green Hydrogen-The Energy of Future

Anusha M K[1],Ashwini C N[1],Priyanka Y R[1],Vinutha A R[1],Amrutha S[1],Darshan G P[1], Dajied kynsai susngi[1]

[1]Department of Electrical and Electronics Engineering, PESCE, Mandya

ABSTRACT

Over the past few years, awareness about the need for coordinated action to limit the ill effects of global warming has increased globally. Most large economies, including India, have committed to net zero carbon emission targets to contribute to this cause. Being the third-largest emitter of carbon dioxide (CO_2) globally, India has taken multiple initiatives to lower its carbon footprint and attain net zero emissions by 2050. The government is prioritising the adoption of green hydrogen for this cause, especially to decarbonise sectors such as ammonia, refineries, iron and steel, methanol, and heavy-duty trucking.India has emerged as one of the global leaders in combating climate change in recent years, and its adoption of green hydrogen is expected to spearhead this movement. During India's 75th Independence Day Celebrations in August 2021, Prime Minister Mr. Narendra Modi announced the National Hydrogen Mission, the country's first major step towards green hydrogen adoption. He laid out the 25-year roadmap for the development of hydrogen in the country and stated his intention to develop India into a global hub for green hydrogen production and export.

KEYWORDS

Green hydrogen, Electrolysis, Government initiative, Scenario analysis, De-Carbonizing.

1INTRODUCTION

Hydrogen, the first member of the periodic table, is the lightest and most abundant element found in the environment. Like electricity, hydrogen is a form of energy that needs to be created from another substance. Water, fossil fuels, or biomass can all be used to produce hydrogen, which can then be separated and used as a fuel or source of energy [4].

One method of producing hydrogen is electrolysis, where an electrical current is used to separate hydrogen and oxygen in water. If renewable sources (solar, wind, hydro, etc.) are used to produce electricity for this process, the hydrogen generated is considered 'green', as there are no carbon emissions during the entire production process, making green hydrogen one of the cleanest fuels currently available[1].

At present, the annual global demand for hydrogen stands at 70 million metric tons, 76% of which is produced from natural gas, 23% from coal, and the remaining from the electrolysis of water. The aim is to increase hydrogen production by the electrolysis method and reduce production via the other two methods. Cost parity between green hydrogen and hydrogen derived from natural gas can be achieved by 2030, if not earlier [2].

2PRODUCTION OF GREEN HYDROGEN

Electrolysis is a promising option for carbon-free hydrogen production from renewable and nuclear resources. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyser. Electrolysers can range in size from small, appliance-size equipment that is well-suited for small-scale distributed hydrogen production to large-scale, central production facilities that could be tied directly to renewable or other non-greenhouse-gas-emitting forms of electricity production [14].

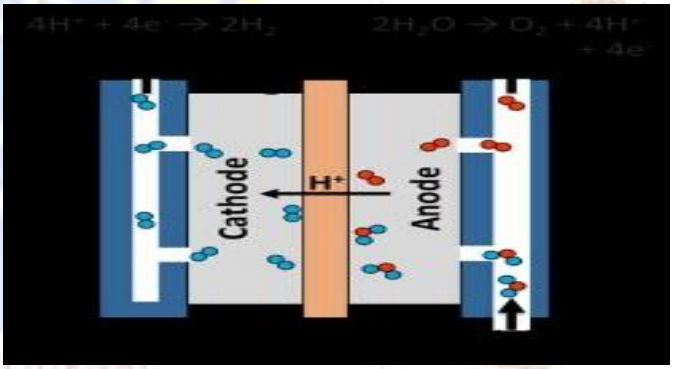

Figure 1: Breakdown of Water molecule into Hydrogen

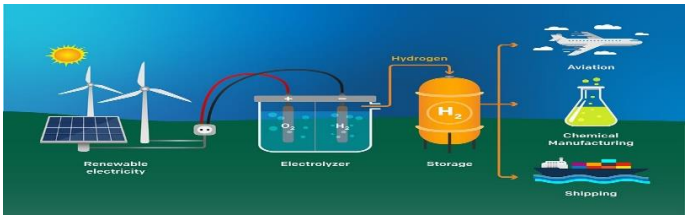

Figure 2: Production of Green Hydrogen

3 GOVERNMENT INITIATIVES

The government understands that hydrogen production requires a lot of energy, and producing green hydrogen using renewable sources is critical to ensuring the country's sustainable energy security. Additionally, increasing hydrogen production provides an impetus to renewable energy capacity development. This will help reduce reliance on fossil fuels and the need to import crude oil. The government aims to manufacture five million tonnes of green hydrogen by 2030. It has taken various measures to achieve this target:

3.1 National Hydrogen Mission: The mission was launched to help India achieve its climate targets and transform it into a green hydrogen hub. Some important details of the policy are as follows:

Manufacturers can purchase renewable power from outside or set up renewable capacity themselves.

A manufacturer of green hydrogen has the option to store any excess renewable energy for a maximum of 30 days with the distribution company, and then retrieve it as needed.

To avoid any delays in the process, the producers of green hydrogen and the renewable energy plant will be granted priority access to the grid.

Renewable Purchase Obligation (RPO) incentive will be granted to hydrogen manufacturers.

A single platform for promptly completing all tasks (including statutory approvals) would be established by the Ministry of New and Renewable Energy to ensure ease of doing business.

Inter-state transmission charges will be waived for 25 years [6].

Potential Roadmap for Green Hydrogen Adoption in India (Source: NITI Aayog)

3.2 International Climate Summit: On September 3, 2021, the first International Climate Summit was convened in New Delhi. The PHD Chamber of Commerce and Industry organised the summit, with Innovation Norway being the country partner. The summit was highly successful, and the Government of India accepted many of the major takeaways for introducing green hydrogen across the nation. In 2022, the summit is scheduled to be held in Bergen, Norway, from August 30-31[10].

3.3 Hydrogen Fuel Trains: The Indian Railways Organization for Alternate Fuels (IROAF) has called for proposals to develop a hydrogen fuel cell-based hybrid power train to convert the 700 HP diesel-hydraulic locomotives operating on the Kalka-Shimla narrow-gauge stretch in Himachal Pradesh [1].

3.4 Hydrogen Fuel Buses: NTPC Ltd, India's largest power producer and a central PSU under the Ministry of Power, has issued a global request for Expressions of Interest (EoI) to supply 10 hydrogen fuel cell-based electric buses and 10 hydrogen fuel cell-based electric vehicles in Leh and Delhi [1].

3.5 Green Hydrogen Mobility Project: On July 30, 2022, Prime Minister Mr. Narendra Modi laid the foundation stone for the Green Hydrogen Mobility Project in Leh, as well as the Kawas Green Hydrogen Blending with Natural Gas project in Gujarat. The former is a test project in which five fuel cell-infused buses will fly around Leh, and the latter is India's first green hydrogen blending project, which aims to reduce the amount of natural gas consumed[2].

Figure 3: Seasonal Storage

4 SCENARIO ANALYSIS OF ENVIRONMENT

Green hydrogen can produce high-temperature heat to power enormous industrial processes-all while emitting zero greenhouse gases. Unlike other types of hydrogen, which are made with coal and conventional natural gas, green hydrogen is produced using renewable electricity.

4.1 Technological innovation: To deploy green hydrogen at a large scale, innovation to lower costs and increase efficiencies across combustion, storage, and transportation will be critical [12].

4.2 Market development: It is important for large corporate energy users, especially in heavier industrial sectors, to signal stronger demand for green hydrogen. Developing new business models will be necessary to drive investment in this fledgling market. In the long run, standardized contracting practices will also make it easier for more energy users to buy green hydrogen. Better environmental, health, and safety standards: Hydrogen is the smallest molecule. It can easily pass through materials, creating leakage issues. And while hydrogen production does not generate greenhouse gas emissions, hydrogen combustion, like any combustion reaction that heats air to high temperatures, creates harmful pollutants called nitrogen oxides. These are linked to smog, acid rain, and damaging health impacts such as asthma and respiratory infections. To address these issues, more stringent environmental, health, and safety standards need to be implemented throughout green hydrogen production, storage, transportation, and use. Communities of colour and low-income communities are disproportionately affected by the impacts of climate change and air pollution. To ensure that the hydrogen market is growing in a just and equitable way, local communities and affected workforces should be meaningfully engaged and included in the design and development of hydrogen projects[14].

4.3 Policy support: There's a big reason to expect rapid advances in the coming years. Last year's landmark federal climate legislation, known as the Inflation Reduction Act, will make green hydrogen a lot less expensive over the course of the decade. Its cost is similar to that of conventional natural gas and fossil fuel-based hydrogen and is expected to continue to fall. Numerous legislative proposals to advance the use of hydrogen were introduced during the last Congress. We anticipate seeing similar proposals introduced during the 118th Congress. As the world struggles to address the worsening climate crisis, we need to think big. Green hydrogen has the potential to decarbonize heavy industry, a sector whose emissions have proved to be some of the most difficult to tackle. Equitable development and deployment of hydrogen energy could make a real impact toward combating the climate crisis while supporting a just energy transition for communities [13].

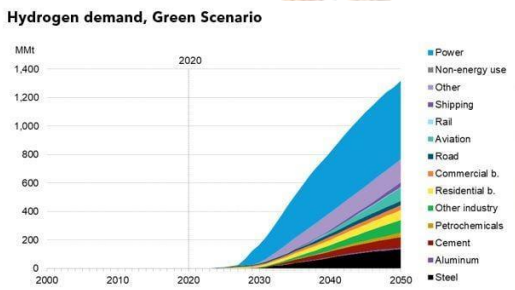

Fig 4: Hydrogendemand, Green scenario

The high cost of production is the main factor behind the low use of green hydrogen. Nonetheless, the United States Department of Energy forecasts that the hydrogen market is expected to grow, with the cost of hydrogen production falling from $6/kg in 2015 to as low as $2/kg by 2025. The price of $2/kg is considered a potential tipping point that will make green hydrogen competitive against other fuel sources. Siemens has already developed offshore wind turbines which are equipped for a hydrogen blend and, consequently help increase production of green hydrogen. The majority of hydrogen produced globally in 2020 is derived from fossil fuel sources with 99% of hydrogen fuel coming from carbon-based sources, and is not green hydrogen. Green hydrogen has significantly lower carbon emissions than grey hydrogen, which is produced by steam reforming of natural gas and represents 95% of the market. On the contrary, green hydrogen, specifically, that produced by electrolysis of water represents less than 0.1% of total hydrogen production [16].

5 DRAWBACKS

- **Safety Concerns:** Hydrogen is one of the most highly flammable and volatile substances .It is colourless and odourless, which makes any leak detection almost impossible.
- **Expensive:** The cost of hydrogen production compared to fossil fuels is more competitive, and the process of electrolysis, which is used to make green hydrogen, is more expensive than both grey and blue hydrogen. High cost.
- **Difficulty in Transport:** Hydrogen is extremely light and has a low volumetric energy density. Making it lighter than helium. At the same time is 2700 times less energy-dense than gasoline. Gasoline is easily transportable through pipelines and shipping containers. There is yet to be a solution found for hydrogen on that front [5].

6 FUTURE OUTLOOK

Due to its advantageous geographic location and the presence of an abundance of natural resources, India has a significant advantage in the production of green hydrogen. India also benefits from low-cost renewable power and rapidly decreasing electrolyser prices. Green hydrogen production can be made cost-effective in India by adding the necessary capacity for renewable power generation, storage and transmission. This will steadily enhance India's self-sufficiency while ensuring energy security [16].

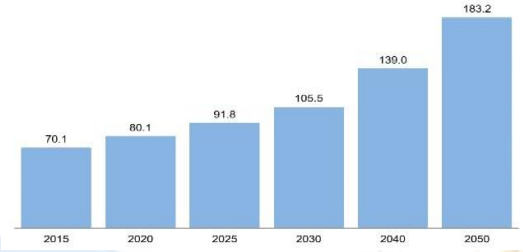

Fig 5: Cost and Computation

Carbon emissions are estimated to increase by 1.5 billion tons in 2021; adopting green hydrogen will help reduce these emissions. India can reduce its CO2 emissions by 3.6 gigatonnes between now and 2050 using green hydrogen. The country could use this as a key tool to further its recently unveiled climate ambitions and achieve its 2070 net zero carbon target [15].

If India's hydrogen adoption plan goes forward as planned, it is estimated that investments of US$ 1 billion can be expected in hydrogen research and development to allow game-changing innovations for the entire world. Green hydrogen can significantly help India combat climate change, supported by proactive collaboration among innovators, entrepreneurs, and the government. It can also help the country export high-value green products, making India one of the first major economies globally to industrialise without 'carbonising'[15].

6 CONCLUSIONS

Green hydrogen is a clean energy source that only emits water vapour and leaves no residue in the air, unlike coal and oil. Benefits of using green hydrogen as a fuel-it is a clean energy. The only waste generates is water. It is a renewable energy. It uses natural resources that are not exhausted. It is storable. It could solve the energy transfer issue for renewables and be used in fuel cells to produce electricity for power generation, transport and domestic heating. In the future, clean-burning hydrogen could also be used to decarbonize heavy industry.It is important to note that today we produce significant amount of grey hydrogen, with high CO2 (and methane) emissions: priority would be to start decarbonizing existing hydrogen demand, for example by replacing ammonia from natural gas with green ammonia.the main actions to accelerate decarbonisation between now and 2030 are 1) energy efficiency 2) electrification with renewables 3) rapid acceleration of

renewable power generation (which will further reduce the already low cost of renewable electricity) 4) scale up of sustainable, modern bioenergy, needed - among others - to produce green fuels that require CO2 5) decarbonisation of grey hydrogen with green hydrogen, which would bring scale and reduce the cost of electrolysis, making green hydrogen competitive and ready for a further scale up in the 2030s, towards the objective of reaching net zero emissions by 2050.

REFERENCES

1. Aakko-Saksa, P.T., Cook, C., Kiviaho, J., Repo, T., 2018. Liquid organic hydrogen carriers for transportation and storing of renewable energy – Review and discussion. J. Power Sources 396, 803–823.https://doi.org/10.1016/j.jpowsour.2018.04.011

2. Agarwal, A.K., Gautam, A., Sharma, N., Singh, A.P., 2019. Methanol and the alternate fuel economy.

3. Amprion, 2019. Press Release: Amprion und OGE treibenihr Power-to-Gas-Projekt “hybridge” voran.Andersson, J., Grönkvist, S., 2019. Large-scale storage of hydrogen. Int. J. Hydrog. Energy 44, 11901–11919. https://doi.org/10.1016/j.ijhydene.2019.03.063.

4. Systems and Structure Division, Energy Conservation and Renewable Energy Department, Agency for

5. Natural Resources and Energy. ARENA, 2018. Opportunities for Australia from Hydrogen Exports. Australian Renewable Energy Agency.

6. National Hydrogen Roadmap. Commonwealth Scientific and Industrial Research Organisation (CSIRO),Australia. Patricia S. Abril and Robert Plant, 2007. The patent holder's dilemma: Government of the Netherlands (2020), Government Strategy on hydrogen, https://www.government.nl/documents/publications/2020/04/06/government-strategy-on-hydrogen.

7. Hydrogen Council (2020), Path to Hydrogen Competitiveness Cost Perspective, Hydrogen Council,www.hydrogencouncil.com/wp content/uploads/2020/01/Path-to-Hydrogen Competitiveness_Full-Study-1.pdf.

8. IEA (International Energy Agency) (2019), The Future of Hydrogen, IEA, Paris. Ikäheimo, J. et al. (2018), “Power-to-ammonia in future.

9. IRENA (2020a), Global Renewables Outlook: Energy Transformation 2050 (Edition: 2020), International Renewable Energy Agency, Abu Dhabi.

10. IRENA (2020b), Reaching Zero with Renewables: Eliminating CO2 Emissions from Industry and Transport in Line With the 1.5°C Climate Goal, International Renewable Energy Agency, Abu Dhabi.

11. IRENA (2019a), Hydrogen: A Renewable Energy Perspective, International Renewable Energy Agency, Abu Dhabi.

12. IRENA (2018), Hydrogen from Renewable Power Technology Outlook for The Energy Transition, International Renewable Energy Agency, Abu Dhabi.

13. IRENA, IEA and REN21 (Renewable Energy Policy Network for the 21st Century) (forthcoming), Renewable Energy Policies in a Time of Transition: Heating and Cooling, IRENA, OECD/ IEA and REN21.

14. RVO (2020), Stimulation of sustainable energy production and climate transition (SDE++), https://english.rvo.nl/subsidiesprogrammes/ sde. Shumkov, I. (2020), “Record low bid for 2-GW solar project shines in Abu Dhabi”, Renewables Now, www.renewablesnow.com/news/record-low-bid-for-2-gw-Solar-project-shines-in-abudhabi- 696804/.Staffell, L. et al. (2018), The role of Hydrogen and Fuel Cells inthe Global Energy System, The Royal Society of Chemistry,www.pubs.rsc.org/en/content/articlepdf/2019/ee/c8ee01157e.Turcotte, I., Gorski, J. and Riehl, B. (19), “Carbon Emissions: Who makes big polluters pay”, The Pembina Institute, (November), p. 27.US DOE (Department of Energy) (2017), Fuel Cells Sub-Program Overview, United States Hydrogen and Fuel Cells

15. WEF (World Economic Forum) (2020), Insight Report: The Net-Zero Challenge: Fast-Forward to Decisive Climate Action, World Economic Forum in collaboration with Boston ConsultingGroup,www3.weforum.org/docs/WEF_The_Net_Zero_Challenge.pdf.

15. Beretta, G. P. (2007). World energy consumption and resources: an outlook for the rest of the century.

16. Hawksworth, J. (2006). The world in 2050: Implications of global growth for carbon emissions and climate change policy, Price Waterhouse Coopers.IEA (2009). World Energy Outlook.