Green Hydrogen Scope for Indian Mission

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Abstract- Hydrogen and Ammonia are envisaged to be the future of fuels and are envisaged to replace fossil fuels in the years to come. One of the major requirements of environmentally sustainable energy security of the nation is production of these fuels by using power from renewable energy sources. This is known as Green Hydrogen and Green Ammonia. Hydrogen is a clean energy carrier that can play an important role in the global energy transition. Its sourcing is critical. Green hydrogen current petroleum-based vehicle engines.

from renewable sources is a near-zero carbon production route. Important synergies exist between accelerated deployment of renewable energy and hydrogen production and use. There is an increased consensus around the world that concerted steps need to be taken to reduce global warming to levels less than 2°C and if possible to cap it at 1.5°C higher than pre-industrial levels. Various countries have pledged their Nationally Determined Contributions in order to ensure energy transition and reduce emissions. Most large economies including India have committed to net zero targets. Transitioning to Green Hydrogen and Green Ammonia is one of the major requirements for reduction of emissions. Government of India has had under consideration a number of policy measures in order to facilitate the transition from fossil fuel / fossil fuel-based feed stocks to Green Hydrogen / Green Ammonia both as energy carriers and as chemical feed stock for different sectors. In this regard, a Green Hydrogen policy has been framed by Ministry of Power for compliance and implementation by concerned stakeholders.

Keywords- Green Hydrogen, Indian Mission, Green Economy, Emission, Climate Change, Global Warming.

INTRODUCTION

During primeval times good amount of CO_2 was present in earth" atmosphere, when water condensed to form oceans and CO2 dissolved in the water forming carbonates. Subsequently CO2 level descreased with the evolution of photosynthetic organisms. In fact the evplution of earths atmosphere has been intimately linked with the development of life on earth.There are couple of reasons for rise of global CO2 level. The burning of fossil fules and the changing of land use pattern are the two important events that are intimately associated with global CO2 rise.

With the Cultural and technological revolution came the automobile, totaling 53 million in the 1950's world automobiles in 2022 exceed 1550 million About 19 million vehicles are added each years to the global total. Automobiles have come to mankind as a mixed blessing. While they enable mankind to conquer distances they also caused blatant destruction of the human environment, poisoned the atmosphere and made human beings vulnerable to several diseases, road accidents and facilities. Global warming is an issue; the whole world is trying to resolve. India and China both represent around 36% of the total world population. India is also one of the largest emitters of greenhouse gases in the world. Considering, the population and pollution, it is the responsibility of India to take important steps to limit global warming. The burning of crude oil is one of the major reasons behind the large emission of greenhouse gases in India. To tackle the issues associated with global warming, many countries are now adopting the concept of a green economy. Hence, to effectively contribute to controlling global warming along with other countries, India also needs to shift its focus on a green economy [1].

Globally, the automobile sector alone is responsible for 24% of CO2 emissions while in India it

Contributes to 13.5% of total CO2 emissions. General environmental management by reducing the net carbon emissions from the transport sector is an important consideration in the green economy. To achieve a target of zero-emission, a hydrogen-based economy can make a great impact. Despite many advantages, the hydrogen-based green economy is still facing many challenges including hydrogen storage, commercialized acceptance in the Indian market, standards, regulating policies, safety, and cost. The

low volumetric density of the hydrogen is the basic issue with its storage and limits the storage amount of hydrogen on board. The cost of fuel cell stack is a major concern, recently due to the developments and research, the cost of fuel cells has slightly reduced and is expected to be reduced further in future time. The mass production and cost-effective non-platinum catalysts can help to bring the cost down considering the future scope of hydrogen in energy transition the current review work presents opportunities for India in the energy sector. Section 2 of the context represents the hydrogen as a future fuel option and focuses on hydrogen production, its storage and PEMFCs. Section 3 of the review is focused on using green hydrogen energy for Indian automobiles sector, its importance, and benefits. Section 4 of the review describes the opportunities for India in hydrogen energy and challenges related to them.

Opportunities for India in Green Hydrogen Economy and Challenges

Based on India's current progress in the renewable energy sector, it is clear that green hydrogen will make a greater impact on India's overall energy sector. Green hydrogen will help to provide a sustainable solution for the Indian transport sector. The Energy and Research Institute (TERI) of India has predicted that the demand for hydrogen will increase from 6 Mt to 28 Mt by 2050 and the cost of hydrogen from renewables will fall by 50% by 2030. TERI claimed that about 80% of hydrogen in India will be produced from renewables by 2050 [32]. India has fewer reserves of natural gas and green hydrogen production from renewables can make a difference in this scenario. Under the 'Make in India' program, India has the opportunity to start the production of electrolyzers and fuel cells which will allow capturing a large share in this market worldwide. As compared to other parts of the world, India has a low cost of electricity from the solar photovoltaic systems; this generated power in the future will be helpful to scale up green hydrogen production. Water consumption by electrolyzers is another issue that needs to be discussed. Electrolyzers consume about 9 liters of water to produce 1 kg of hydrogen. In this scenario, seawater electrolysis may be helpful that requires further development and research work

The existing hydrogen infrastructure is not enough to promote the larger acceptance of fuel cell vehicles. For further developments, hydrogen refueling stations will be playing a very important role. At the end of 2019, there were 470 operating hydrogen refueling stations in the world. Countries like Japan Germany, the United States, and China have a large number of hydrogen stations. Currently, India has only two established hydrogen refueling stations one at the Indian Oil R&D Center, Faridabad, and the second at the National Institute of Solar Energy, Gurugram. To give a boost to the public acceptance of fuel cell vehicles in India, the number of hydrogen fuel stations need to be increased. For a country like India with its growing economy, controlling pollution and energy security is an important issue. In this scenario, the great potential of hydrogen is far away from gaining popularity in India. India is exploring renewables especially solar, wind and hydropower but hydrogen application is still not in focus. Many Indian institutions including the Indian Space Research Organization (ISRO), Indian Oil Corporation (IOCL), Bharat Heavy Electricals Limited (BHEL), and Tata Motors are actively working on hydrogen and fuel cell technologies. This ongoing research will help India to face challenges regarding fuel cell acceptance, regulations, and standards formulations, etc. [3]. Most of the sustainable energy technologies are developed and manufactured outside India. However, the sizable renewable power generation capacity of the country provides the opportunity to produce green hydrogen and maximize the benefits from the energy transition. In the future, India will see huge growth in the heavy transport sector Features of fuel cell electric trucks like zero carbon emissions with long-range travel and fast refueling time make these trucks better alternatives for diesel trucks for the Indian heavy transport sector. The increase in the use of locally produced green hydrogen can significantly reduce the dependency on petroleum imports in India. In the same scenario, Table 4 of the context shows some important benefits, opportunities, and challenges of shifting to hydrogen energy.

National Hydrogen Mission: Aim ((Source: National Hydrogen Mission Ministry of New & Renewable Energy)

- The proposed National Hydrogen Energy Mission aims to lay down the vision, intent and direction for harnessing hydrogen energy by the Government of India.

- The aim is to develop India as a global hub for manufacturing of hydrogen and fuel cells technology across the value chain.
- The mission would put forward specific strategy for the short term (four years), and broad strokes principles for long term (10 years and beyond).
- It will provide necessary flexibility to capture benefits from the advances that are taking place in the technological landscape.
- The Government of India will facilitate demand creation in identified segments. Possible areas include suitable mandates for use of green hydrogen in industry such as fertilizer, steel, petrochemicals etc.
- Major activities envisaged under the mission include creating volumes and infrastructure; demonstrations in niche applications including transport and industry; goal-oriented research & development; facilitative policy support; and putting in place a robust framework for standards and regulations for hydrogen technologies.
- The mission aims to aid the government in meeting its climate targets and making India a green hydrogen hub. This will help in meeting the target of production of five million tonnes of Green hydrogen by 2030 and the related development of renewable energy capacity.

Green Hydrogen & Green Ammonia Policy: A Key Step in National Hydrogen Mission.

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There is an increased consensus around the world that concerted steps need to be taken to reduce global warming to levels less than 2°C and if possible to cap it at 1.5°C higher than pre-industrial levels. Various countries have pledged their Nationally Determined Contributions in order to ensure energy transition and reduce emissions. Most large economies including India have committed to net zero targets. Transitioning to Green Hydrogen and Green Ammonia is one of the major requirements for reduction of emissions. Government of India has had under consideration a number of policy measures in order to facilitate the transition from fossil fuel / fossil fuel-based feed stocks to Green Hydrogen / Green Ammonia both as energy carriers and as chemical feed stock for different sectors. In this regard, a Green Hydrogen policy has been framed by Ministry of Power for compliance and implementation by concerned stakeholders.

Hydrogen Energy

Hydrogen is emerging as an important source of energy since it has zero carbon content and is a non-polluting source of energy in contrast to hydrocarbons that have net carbon content in the range of 75–85 per cent. Hydrogen energy is expected to reduce carbon emissions that are set to jump by 1.5 billion tons in 2021. It has the highest energy content by weight and lowest energy content by volume. As per International Renewable Energy Agency (IRENA), Hydrogen shall make up six per cent of total energy consumption by 2050. The Hydrogen Council Report, 2021 also mentions that, global investments on hydrogen will constitute around 1.4 per cent of the total global energy funding by 2030. The current global demand for hydrogen is 70 million metric tons per year, more than 76 per cent of which is being produced from natural gas, 23 per cent comes from coal and the remaining is produced from electrolysis of water.

Grey Hydrogen, Blue Hydrogen, Green Hydrogen: A Comparison

Hydrogen is primarily used in petrochemicals and fertiliser industry and is produced largely from natural gas, thereby emitting enormous amounts of carbon dioxide. Depending on the nature of the method of its extraction, hydrogen is categorised into three categories, namely, grey, blue and green. There is a growing focus on increasing production of green and blue hydrogen due to its no carbon emission and use of carbon offset technology, respectively. Additionally, several leading organizations are exploring technologies which can convert bio and plastic waste into hydrogen, thereby providing a huge scope for investment in this technology which can combat India's twin problems of waste management and energy security Where the hydrogen comes from is important. At the moment, it's mainly produced industrially from natural gas, which generates significant carbon emissions. That type is known as "grey" hydrogen. A cleaner version is "blue" hydrogen, for which the carbon emissions are captured

and stored, or reused. The cleanest one of all is "green" hydrogen, which is generated by renewable energy sources without producing carbon emissions in the first place.9

India Advancing Towards a Cleaner Future: The Role of Hydrogen Energy

India has a huge edge in green hydrogen production owing to its favourable geographic conditions and the presence of abundant natural elements.

- The Government has given impetus in scaling up the gas pipeline infrastructure across the length and breadth of the country and has introduced reforms for the power grid, including the introduction of smart grids. Such steps are being taken to effectively integrate renewable energy into the present energy mix.
- With appropriate capacity addition to renewable power generation, storage and transmission, producing green hydrogen in India can become cost-effective which will not only guarantee energy security but also ensure self-sufficiency gradually.10
- Setting the right priorities for hydrogen use will be essential for its rapid scale-up and long-term contribution to decarbonization efforts. Hydrogen is part of a much bigger energy transition picture, and its development and deployment strategies should not be considered in isolation.
- A shift to large-scale use of hydrogen fuel can help bolster India's geopolitical heft and support energy security. More than 30 countries and regions have hydrogen strategies that include import or export plans, indicating that cross-border hydrogen trade is set to grow considerably

Hydrogen: The Indian Context –

- Hydrogen for integrating Renewable Energy

Hydrogen provides a means for storage of variable renewable energy for stabilizing its output. For long duration storage, running into several hours, converting excess available energy into hydrogen and utilizing it for grid support and other applications is seen to be a suitable alternative.

- Hydrogen in Industry

In industry, hydrogen can potentially replace the coal and coke in iron and steel production. Steel manufacturing is one of the largest carbon emitters in the world, decarbonising this sector using hydrogen is expected to have significant impact on our climate goals.

- Hydrogen has potential to reduce fossil fuel imports .
- At present, hydrogen produced from natural gas is widely utilized for production of nitrogenous fertilizers, and petrochemicals. Substituting this with green hydrogen could allow use of renewable energy in these important sectors and reduce import dependence.
- India's annual Ammonia consumption for fertilizer production is about 15 million tonnes, roughly 15 per cent of this demand (over 2 million tonnes per annum) is currently met from imports. Mandating even 1 per cent green ammonia share is likely to save about 0.4 million standard cubic feet per day of natural gas import.
- Use of hydrogen in steel industry could substitute imported coking coal. During 2018-19, the total demand of coking coal for the steel industry was 58.37 million tonne (MT). Out of this, 51.83 MT was met through imports.
- While Battery Electric Vehicles (BEVs) are dependent on imported raw materials like lithium and cobalt for lithium-ion batteries, the hydrogen fuel cell supply chain can be wholly indigenized, making India Aatmanirbhar in the clean transportation segment.
- Hydrogen-based Transport

  Fuel cell electric vehicles (FCEVs) run on hydrogen fuel and have no harmful emissions. Battery Electric Vehicles (BEVs) may be suitable for light passenger vehicle segment for shorter driving range. For heavy duty vehicles with longer trip range, such as buses, trucks and other commercial vehicles, FCEVs are likely to become cost competitive in the coming years.

India's Progress towards Green Hydrogen13

- Prime Minister Narendra Modi aims to transform India into an energy independent nation by 2047 where green hydrogen will play an active role as an alternate fuel to petroleum/ fossil-based products.
- In 2020, India's hydrogen demand stood at 6 million tonnes (MT) per year. It is estimated that by 2030, the hydrogen costs will be down by 50 per cent.

- The demand for hydrogen is expected to see a five-fold jump to 28 MT by 2050 where 80 per cent of the demand is expected to be green in nature.
- Some of the prominent industrial mammoths such as Reliance Industries Limited (RIL), Gas Authority of India Limited (GAIL), National Thermal Power Corporation (NTPC), Indian Oil Corporation (IOC) and Larsen and Toubro (L&T) plan to foray into the green hydrogen space. RIL plans to become a net-carbon zero firm by 2035 and invest nearly INR 750 billion over the next three years in RE.
- India has declared its ambition to become an exporter of hydrogen to Japan, South Korea, and Europe.

CONCLUSION

India has a large growing population and economy, but comparatively has limited availability of fossil fuels to fulfill its energy demands. The consumption of fossil fuels is contributing to the heavy emission of greenhouse gases. A large number of vehicles that are based on petroleum are the major reason for increased petroleum imports in India. To reduce the environmental pollution and petroleum imports in India, there is a need to look for an alternate fuel for the transport sector. Considering the need to search for an alternate fuel, the context focuses on the opportunities offered by Green Hydrogen Economy and related challenges. The concept of Green hydrogen economy brings many opportunities for India to become energy independent

For the last decade, India is constantly focusing on growing its renewable energy capacity by taking advantage of its geography. Integrating hydrogen production with these renewable can scale up the green hydrogen production in India. India can take the advantage of its renewable energy scenario and can scale up its hydrogen production facilities. The mass production offers India an opportunity to export green hydrogen to other nations. Green Hydrogen when used with fuel cells can help India significantly reduce its petroleum imports and environmental pollution. Renewable energy in India provides the opportunity to produce green hydrogen and to develop hydrogen infrastructure but for adoption, many challenges still need to be solved. These challenges include hydrogen production cost, storage, transportation, policies, regulations, public awareness, etc. The world is slowly moving towards the adoption of a Hydrogen economy and India is also taking important initiatives. Indian organizations which include both government and public are investing in the research of hydrogen technologies. Many Ongoing research and demonstration projects are very important to develop hydrogen and fuel cell technology economically. The progress in this development will play a key role in the commercialization of the technology. Well-developed fuel cell technology and locally produced green hydrogen will be key players to decarbonize the Indian transport sector by replacing the current petroleum-based vehicle engines.

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