Shaping a Hydrogen Energy Future for India

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ABSTRACT
India is committed to become ATMA-NIRBHAR i.e. self-sufficient in energy sector also with predominant share of green energy. Presently, the main source of energy in India is the coal based power plants. The fossil fuels have two fold constraints, viz. environmental concerns and their fast depleting deposits. The renewable energy resources do not suffer from such constraints. However, the predominant renewable sources, viz. wind and solar are variable in nature and hence, cannot produce reliable power. There is a great awareness and initiative in several countries to go all out for green hydrogen to replace fossil fuels i.e. to move towards net zero carbon. There are certain challenges also with hydrogen which are discussed in this paper along with the efforts being made to overcome them.

Key words: Renewable energy, future energy, green hydrogen, electric vehicles.

I INTRODUCTION

Hydrogen is not available in free form in the atmosphere but it is a part of the atmospheric air in the form of a water vapour. In the warm and wet tropics, the water vapour may be 4% of the air by volume, while it may less than even 1% in the dry and cold areas of deserts and Polar Regions. Water vapour also decreases from the equator towards the poles. The composition of atmospheric air is shown in Figure 1.

In fact, main source of hydrogen is the water which is available underground and also on the surface of earth in abundance in the water bodies like tanks, streams, rivers, and of course sea.

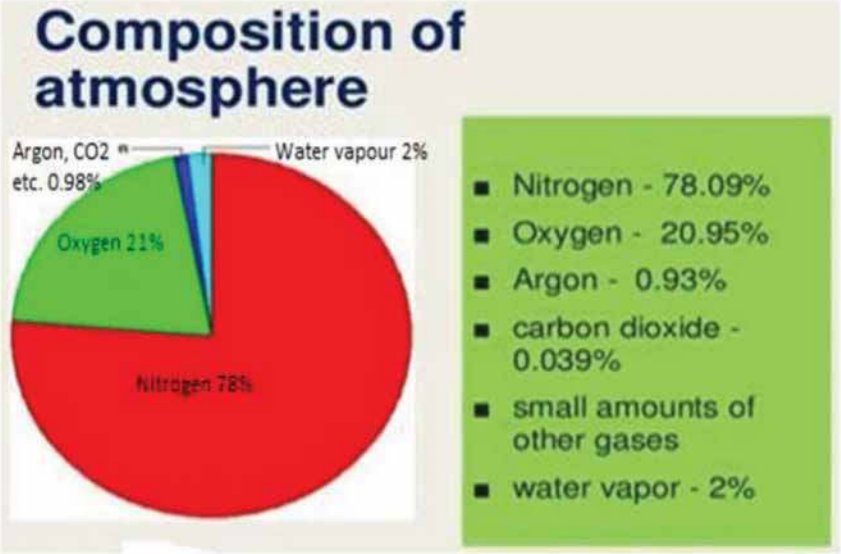

Fig. 1 Composition of air in the atmosphere [1]

The technologies are available to extract hydrogen from water, water vapour or organic compounds and research continues to develop cost effective and eco-friendly technologies.

Power generation from renewable energy (RE) sources i.e. solar, wind, hydro, geothermal, biomass is being encouraged to increase rapidly to enable it to play important role in decarbonizing the power sector. The green hydrogen i.e. the hydrogen produced from renewable energy must increase tremendously to cater for the needs of industry and heavy transport sectors.

Water and Organic compounds are the main sources of hydrogen and it can be produced in two ways:

(a) Most of the hydrogen produced in the world including India is by steam methane reforming (SMR) of the natural gas. The hydrogen produced by SMR and the emissions are released in the atmosphere, it is known as grey hydrogen. However, instead of releasing the emissions in the atmosphere, they are captured (85-95%), it is known as blue hydrogen.

(b) If the energy used is renewable then hydrogen produced by such a sustainable eco-friendly carbon free approach is termed as green hydrogen [2].

This paper brings out the challenges related to the hydrogen and key elements of government's policy initiatives for achieving a sustainable energy future.

II POWER SECTOR IN INDIA

India's power generation is dominated by coal whereas the share of power generation from the renewable sources of energy is growing fast and its growth has taken over conventional installed power capacity addition since 2016-17. In India, the main renewable energy (RE) sources are solar, wind and hydro. Solar and wind resources are variable in nature. In order to improve reliable power, the policy to promote wind-solar hybrid power system with energy storage was issued by the ministry of new and renewable energy (MNRE) [3]. Hydro energy offers consistent power subject to the availability of water that depends on rainfall which varies from season to season. As far as hydrogen is concerned, its production technologies are available. However, the production of green hydrogen has become the urgent heed of the hour for sustainable future.

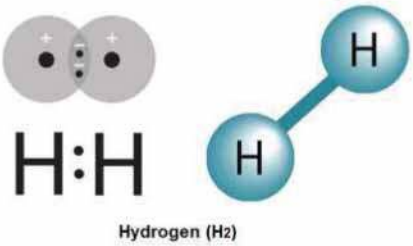

Fig. 2 Structure of hydrogen [4]

Hydrogen can be stored in the form of a compressed gas or liquid and with some modification it can be used in the gas turbines or internal combustion engines. The main properties of hydrogen are given below which are superior to most other fuels:

Specific heat at constant pressure (C_p)	14.32 kJ/kg/K
Specific heat at constant volume (C_v)	10.11 kJ/kg/K
Boiling point	-252.8° C
Melting point	-259° C
Calorific value	120 to 142.7 MJ/kg

The main constraints associated with the hydrogen are given below:

(i) Production cost – Hydrogen is not freely available but has to be extracted from water or hydrocarbons. Hence, the cost of production also plays an important role. The electrolyzers required for electrolysis process to produce hydrogen are costly.

(ii) Storage of hydrogen – It can be stored either as a gas or a liquid. The gas storage requires high-pressure tanks (350–700 bars). The storage in liquid form requires cryogenic temperatures due to low boiling point of -252.8° C at one atmosphere. It can also be stored on the surfaces of solids (by adsorption) or within solids (by absorption) [5].

(iii) Transportation of hydrogen – The safe transportation of hydrogen is challenging as it is highly inflammable. The piping network provides the most economical and fast means of hydrogen transportation. A very few countries, excluding India, have hydrogen pipelines. India has a huge network of natural gas pipelines. They can be used with hydrogen blending (17-18%) in natural gas with minor modifications. However, for transporting pure hydrogen, major modifications are necessary.

(iv) High tech – Lack of adoption of high tech hydrogen based appliances by the industries

(v) Manpower – Lack of trained manpower.

(vi) Other barriers – Barrier from established fossil fuel based power, industry, and transport sector.

(a) Hydrogen energy - Hydrogen is an odourless, colourless non-metal which consists of a proton at the centre in the nucleus of a hydrogen atom and a light electron revolves around it in the orbit. A molecule of hydrogen consists of two protons and two electrons held together by electrostatic forces as shown in Figure 2.

(b) Challenges in adopting hydrogen - The challenges in the adoption of hydrogen are shown in Figure 3.

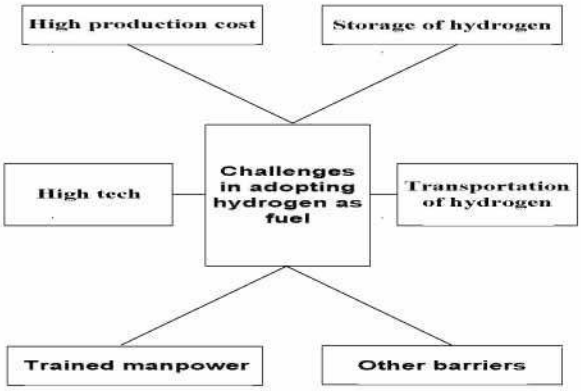

Fig. 3 Challenges in adopting hydrogen as fuel

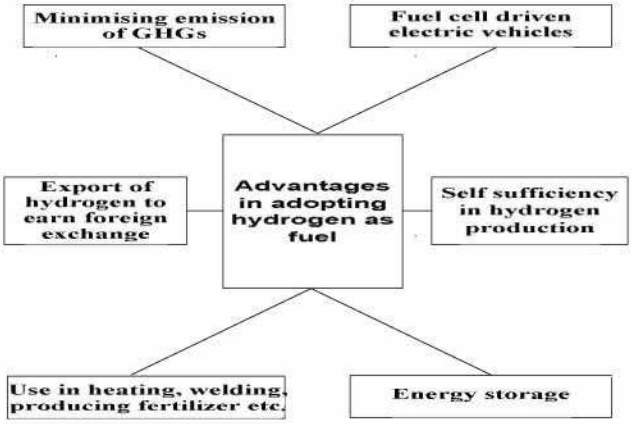

Fig. 4 Advantages in adopting hydrogen as fuel

(c) Uses of hydrogen

The hydrogen has the highest energy density by weight and lowest energy density by volume. It is an important raw material for fertilizer and refineries which are the bulk consumers of hydrogen. In future, it will find place in steel and cement industries. It would power the light and heavy duty vehicles through fuel cells. In future it would be used in aviation, shipping, submarines, and decentralized power generation with fast increasing proportion of green hydrogen. The various present and future applications of increasing proportion of green hydrogen are shown in Figure 5.

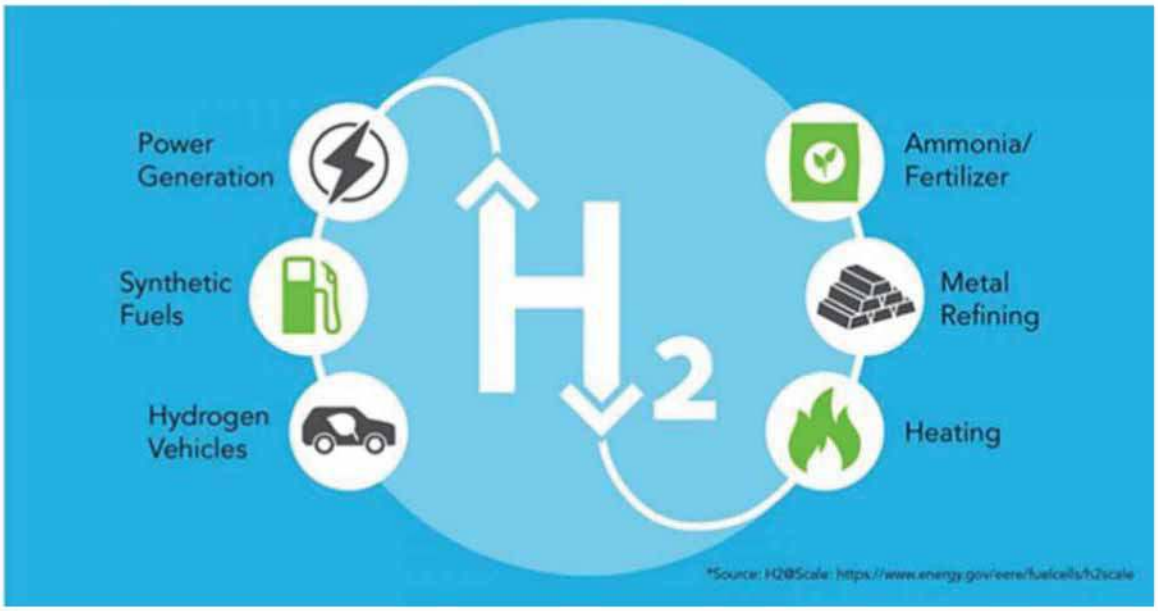

Fig. 5 Uses of hydrogen energy [6]

The uses of hydrogen are given below:

(i) Transport sector: It is one of the most potential sectors for use of hydrogen in fuel cells to drive electric vehicles. It overcomes the disadvantages associated with storage batteries which need frequent charging.

(ii) The oxy-hydrogen flame achieves a temperature of 2800° C and is used for welding and cutting of metals.

(iii) Used for the hydrogenation of vegetable oils to convert it into vanaspati ghee.

(iv) The hydrogen and helium gases are filled in weather observation balloons.

(v) Hydrogen gas is needed for breaking down crude oil into fuel oil, gasoline etc. in the production process of petroleum products.

(vi) Hydrogen is essentially required for the production of ammonia which is used in the fertilizer plant.

(vii) Hydrogen gas is used as a hydrogenating agent for polyunsaturated fats.

III POLICY INITIATIONS

Policy initiations to overcome renewable energy variability using energy storage, electrical vehicle and hydrogen energy.

- The GoI has production linked incentive scheme to promote energy storage [7,8] and has ambitious plans to go full-fledged for electric vehicles [9]. There is a rapid visible growth in battery driven 3-wheelers. Some state governments have also come forward with the attractive subsidies to promote environment friendly electric vehicles. [10,11]
- The lead-acid batteries are conventionally used. However, their disposal is a problem. Alternatively, the lithium-ion batteries can be used in electric vehicles but they are dependent on imported raw materials, mainly lithium and cobalt. In contrast, the hydrogen based fuel cells do not have the problem of frequent charging. Instead, they work till the hydrogen fuel is supplied.

(a) Hydrogen energy

(i) Prime Minister Shri Narendra Modi on August 15, 2021, launched the National Hydrogen Mission on India's 75th Independence Day [12].

(ii) In the Union Budget 2021-22, an amount of Rs. 800 Cr. was allocated for a period of 3 years for R&D and infrastructure development of green hydrogen.

(iii) The Ministry of Power, issued the green hydrogen and ammonia policy on February 17, 2022. Hydrogen and ammonia are considered future fuels to replace fossil fuels.

The R&D efforts have been carried out for several years. There are 37 leading institutions working on over 100 projects related to various aspects of hydrogen. This has resulted in development and demonstration of internal combustion engines for hydrogen driven two wheelers, three wheelers, and mini buses. Two hydrogen refuelling stations have been established (one each at Indian Oil R&D Centre, Faridabad and National Institute of Solar Energy, Gurugram) [13]. It is necessary to make continuous efforts to establish more facilities for research & development, entre into technical collaborations and technology transfer [14]. It is not far when hydrogen distribution network similar to petrol pumps will become a reality.

(b) Budgetary allocations - India has been focusing on environment by increasing the forest cover to improve carbon absorbing capacity. Covid-19, a global pandemic has also underlined the importance of environment and brought it at the centre-stage. The budgetary allocation of Rs. 3,030 crore for Environment in the Union Budget 2022 is an indicative of the concern of the GoI [15]. All out efforts are being made to minimise the emission of greenhouse gases by speeding-up the growth of renewable energy. The energy storage in power sector is encouraged mainly to take care of the variability of wind and solar resources. On the other hand, hydrogen is emerging fast as a potential source of future energy and its use is intended mainly in industries, heavy vehicles and, decentralized power generation to accelerate India's decarbonization journey [16]. These efforts endorse India's latest net zero commitments made in the COP26 summit. The Prime Minister in his Independence Day-2020 speech stated that India would work for the hydrogen economy. The plan is to develop India into global hub for production of green hydrogen and fuel cells. In line with this, GoI has made provision of Rs. 800 crore for 3 years in the Union Budget 2021–22 for the R & D and infrastructure development in hydrogen and intends to produce three-fourths of its hydrogen as green hydrogen by 2050 [17].

IV CONCLUSION

The green hydrogen and green ammonia issued by the Ministry of Power is a great initiative that would pave the way for large scale decarbonization and reduction in the import of fossil fuels, i.e. crude oil, coal, and natural gas. Green hydrogen is at a budding stage but has a great potential for the energy transition. In order to meet the ambitious targets, the judicious but quick decisions would be the prerequisites on developing the infrastructure production, storage, transportation, distribution, and implementing the outcome of R & D on over 100 projects in 37 institutions in India on various aspects of hydrogen. Such initiatives would be instrumental in making hydrogen, a forerunner of future energy.

REFERENCES

[1] Water Vapour: Composition of atmosphere, QS Study https://qsstudy.com/water-vapour-composition-atmosphere/

[2] Rashmi Chaubey, Satanand Sahu, Olusola O. James, Sudip Maity, A review on development of industrial processes and emerging techniques for production of hydrogen from renewable and sustainable sources, Renewable and Sustainable Energy Reviews, Vol. 23, 2013, 443-463.

[3] Amendment in national wind-solar hybrid policy, https://mnre.gov.in/img/documents/uploads/41e72559eb1140d18ad1a082ec050426.pdf.

[4] Hydrogen gas, BYJU's, https://byjus.com/chemistry/hydrogen-gas/

[5] Hydrogen storage, https://www.energy.gov/eere/fuelcells/hydrogen-storage.

[6] Melno Park, 2019. Study shows a much cheaper catalyst can generate hydrogen in a commercial device, https://www.eurekalert.org/news-releases/558053

[7] Energy storage, https://mnre.gov.in/new-technologies/energy-storage.

[8] Energy storage, https://www.livemint.com/industry/energy/india-working-on-an-energy-storage-policy-11634005829830.html.

[9] Electric vehicle policy 2021, Kolkata gazette June 3, 2021 https://wbpower.gov.in/wp-content/uploads/Electric%20Vehicle%20Policy%202021%20(Kolkata%20Gazette%20Notification).pdf.

[10] Delhi: In the works, scheme for electric 3-wheelers, Feb 15, 2021 https://indianexpress.com/article/cities/delhi/delhi-in-the-works-scheme-for-electric-3-wheelers-7188840/#:~:text=carts%20and%20loaders.-,Under%20the%20new%20policy%2C%20incentives%20of%20up%20to%20Rs%207%2C500,of%20the%20pollution%20in%20Delhi.

[11] Electric vehicle sales in India increase by three times in first half of FY22: Report, https://www.news18.com/news/auto/electric-vehicle-sales-in-india-increase-by-three-times-in-first-half-of-fy22-report-4315742.html.

[12] Hydrogen policy, https://www.jagranjosh.com/current-affairs/what-is-national-hydrogen-mission-launched-by-pm-modi-on-15th-august-2021-1629272119-1.

[13] Hydrogen and fuel cell, https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf

[14] Rachel Chamausis, Hydrogen: Fuel of the future, https://www.csustan.edu/sites/default/files/honors/documents/journals/Stirrings/Chamoussis.pdf.

[15] Union budget 2022-23, Environment Ministry, https://economictimes.indiatimes.com/news/economy/policy/union-budget-rs-3030-crore-allocated-to-environment ministry/articleshow/89274698.cms?utm_source=whatsapp_pwa&utm_medium=social&utm_campaign=socialsharebuttons&from=mdr.

[16] Union budget 2022-23 renewable energy, https://www.financialexpress.com/budget/budget-2022-renewable-energy-energy-storage-and-hydrogen-mantra-for-indias-decarbonization-journey/2418438/

[17] India's National Hydrogen Mission and Prospects for Cooperation with GCC, https://www.idsa.in/issuebrief/india-national-hydrogen-mission-n-gcc-lpriya-270821.