Hydrogen: Zero emission Fuel for the Transport & Maritime Sectors

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WHAT IS GREEN ENERGY?

- Green energy is a type of energy generated using natural and renewable resources such as solar, wind power, geothermal energy etc. For an energy to be termed as green, the resource should not be polluting or harmful to the environment in any manner. This means that not all sources used by the renewable energy industry are green.
- For example, while hydropower which is energy generated from fast-flowing water, is renewable, some people argue that the process of generating vast amounts of power from water is not actually green, because of the industrialisation and deforestation involved in the process of building large hydro dams.

WHY DO WE NEED GREEN ENERGY?

- Green energy is important because it is a better and a cleaner replacement for fossil fuels. It replaces the negative effects fossil fuels have on the environment and is a more sustainable alternative. The economic benefits also include job creation in building the facilities that often serve the communities where the workers are employed.
- Extensive research and development are being done by various governments as well as private organizations to create an ideal alternative for fossil fuels. One such element which has successfully shown positive results is HYDROGEN. Hydrogen fuel cells is considered as the next step in the future of sustainable and renewable fuel.

HYDROGEN FUEL: A STEP TOWARDS A SUSTAINABLE FUTURE

- Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind. These qualities make it an attractive fuel option for transportation and electricity generation applications. It can be used in cars, in houses, for portable power, and in many more applications. Replacing the fossil fuels now used in furnaces with hydrogen gas could make a big dent in the 20% of global carbon dioxide emissions that now come from industry.

- The Indian government has also been investing in creating hydrogen-based alternatives through The Ministry of New and Renewable Energy. They have been supporting a broad-based Research Development and Demonstration (R&D) programme on Hydrogen Energy and Fuel. Projects are supported in industrial, academic and research institutions to address challenges in production of hydrogen from renewable energy sources, its safe and efficient storage, and its utilization for energy and transport applications through combustion or fuel cells.

- Today's transport sector is predominantly based on the combustion of fossil fuels, making it one of the largest sources of both urban and regional air pollution. With the introduction of Hydrogen based fuel cells, it will create a significant impact in reducing the carbon footprint of the transport sector worldwide.

- After a lethargic start to climate action over the past decades, there are some signs which the shipping industry is also beginning to pay attention to regarding the risks posed to it by the climate crisis. A large percentage of the industry now think they will need to get off fossil fuels, with hydrogen-derived fuels such as ammonia considered the most likely alternatives.

WHY SHOULD INDIA INVEST IN HYDROGEN FUEL?

A. Investing in hydrogen development would keep India in step with global competition.

B. India could be energy self-sufficient with hydrogen.

C. Converting to a hydrogen-based economy would create thousands of permanent scientific and industrial jobs.

D. Fossil fuels are depleting quickly and will run dry soon. Hydrogen is renewable and, therefore, unlimited. Solving energy supply problems today will ensure our nation's stability tomorrow.

A. Pollution from cars, aeroplanes etc has created smog clouds across many cities of the country. However, Hydrogen emits no toxins and hence does not pollute.

B. Huge oil spills are becoming common, killing countless water creatures. If hydrogen were spilt, it would evaporate immediately. The only by-product of hydrogen fuel is water thereby making it the ideal fuel for ships and submarines.

C. Mass consumption of oil requires continued drilling into pristine wilderness areas, wreaking havoc on some of the world's greatest ecosystems. Whereas Hydrogen production leaves no environmental scars.

SCOPE OF HYDROGEN FUEL IN THE TRANSPORT AND MARITIME SECTOR

- The key pillars of decarbonising the global energy system are energy efficiency, behavioural change, electrification, renewables, hydrogen, and hydrogen-based fuels. According to UN reports, the transport sector is responsible for one-quarter of the global carbon emission and International Shipping itself accounts for almost **3%** of the total global carbon emission. This is because the transport sector is almost fully based on fossil fuels and therefore has become one of the major contributors to the growing carbon footprint of our earth.

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- Hence, it is imperative that we switch to a more sustainable fuel like hydrogen to ensure a global green climate.
- The **International Maritime Organization** (IMO), a United Nations agency, has set targets to reduce its greenhouse gas emission by 50% in 2050 compared to the 2018 baseline emissions. In order to achieve these targets, they mandated a shift from dependence on fossil fuels to an energy mix in the shipping sector that includes low carbon emitting fuels. Countries are focusing on implementing green hydrogen based fuels for transport and maritime sector as it is considered to be a carbon-neutral fuel.

- The Global Maritime Forum's study from March 2021 noted that pilot projects using hydrogen as a fuel source for large ships tripled from 2019 to 2021 and certain Scandinavian countries have also implemented their own emissions regulations to pave way for the hydrogen economy. Their main area of focus is on green hydrogen and its feasibility.

- Green hydrogen could play a crucial role in the maritime industry's journey towards decarbonization. Produced through electrolysis, H2 is free of carbon emissions and could be widely available across the globe in the future as a marine fuel or a key enabler for synthetic fuels.

- Many in shipping recognize hydrogen's potential, but the barriers to implementing H2 technology are substantial.
- Powering vessels with hydrogen can be done via combustion engines, blending hydrogen in with other fuels, or storing it in a liquid organic solution or as ammonia. The most common and greenest way of generating power from H2 is using hydrogen fuel cells. Let us look at how various nations have implemented hydrogen-based fuel in their transport and maritime sectors.

TRANSPORT SECTOR

- Many countries, such as the United Kingdom, Portugal, Belgium, and the Netherlands, are investing in hydrogen production hubs to reduce infrastructure costs and become self-sufficient in the production of hydrogen fuel. The United States is funding 29 hydrogen storage and infrastructure technology pilots through an initiative named **H2@scale**.
- Several automobile brands in the United States are selling or leasing FCVs (Hydrogen Fuel Cell Vehicles) in select markets, primarily in California where some hydrogen fueling stations already exist. Hydrogen infrastructure is also popping up in other locations around the country.

- Stations are being planned or built in the Northeast and Hawaii, and fuel cell transit buses are already cruising the streets in cities like Boston, Massachusetts, and Flint, Michigan. There are plans to expand FCV offerings over the next few years as infrastructure grows and the technology continues to mature.

- In 2019, global hydrogen refueling station which were mostly deployed in Japan, Germany, the US, China, Korea, and France, tallied an increase of 20 percent compared to the previous year.
- Japan introduced **100 hydrogen buses** at the 2020 Tokyo Olympics to carry the participants across various venues. These hydrogen fuel cell buses were manufactured by Toyota and it was part of kicking off Japan's plan of creating a hydrogen economy.
- A public-private sector initiative between **Incheon Metropolitan Government, SK Group,** and **Hyundai Motors** plans to invest over 18 trillion (about $16 billion) in developing large-scale hydrogen infrastructure in Korea, including the construction of fueling stations and a fuel cell power plant, as part of a hydrogen infrastructure. Various green hydrogen production infrastructure deployment projects are underway or have been planned.

MARITIME SECTOR

- Belgium has launched **Hydroville**, a small ferry running between Kruibeke and Antwerp which is powered using hydrogen. Hydroville was launched in 2017 as the world's first hydrogen-powered passenger vessel. Its hybrid engine allows it to run on both hydrogen and diesel. Developed by CMB Tech, a private research and development lab based in Belgium, Hydroville hopes to be a stepping stone in creating a sustainable future in the maritime sector.

- The EU's hydrogen strategy prioritizes investment in research and development through the Fuel Cells and Hydrogen Joint Undertaking, which aims to increase the scale and efficiency of the entire European hydrogen supply chain.

- EU has also introduced **H2Ports** as part of promoting innovation on efficiency and sustainability of seaports. The H2Ports project is an initiative of the Port of Valencia in line with its strategy of port-logistics de-carbonisation, reduction of port carbon footprint and adoption of alternative fuels, which facilitate the transition of ports towards zero-emission operations.

- H2Ports is the first European project focused on testing heavy-duty port equipment powered with Hydrogen Fuel Cells, being also the first port in Europe able to supply this alternative fuel by means of Hydrogen supply infrastructures. The project is funded by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) with 4 million, and is leaded by the Fundación Valencia port, the research and innovation center of the Valencia port cluster. The Port Authority of Valencia is also an active partner in the project.

- Fuel Cell-based solutions for relatively small boat propulsion have been tested successfully. Passenger boats have been demonstrated in many countries such as France, from the lightweight catamaran to small river tourist transportation or water-taxi/bus.
- Fishing boats have also been equipped with hydrogen propulsion. This is being done through the project named FILHyPyNE in France. Several small ferry boats are also currently demonstrated in the frame of other projects as well, named HYBRIDShips and MF Ole Bull and the EU-funded HYSEAS III initiative as well.

HOW CAN HYDROGEN BE USED TO POWER SHIPS?

- It can be burnt in an internal combustion engine, as Hydroville is currently doing. One downside to this is that burning anything in air, which consists largely of nitrogen, inevitably produces some level of nitrogen oxides which are major air pollutants.
- Hydrogen can also be used in a fuel cell, a device that chemically converts the fuel into electricity without the need to burn it, and the only emission is water.

WHAT ARE THE CHALLENGES OF HAVING HYDROGEN AS SHIPPING FUEL?

- Hydrogen is extremely flammable and has a larger ignition range than other traditional fuels, meaning that hydrogen will burn at both low and high concentrations when combined with oxygen. However, there are safety measures that can mitigate this risk during storage, transportation, and ignition.
- Hydrogen, even in liquid form, is less energy-dense than bunker fuel, meaning that hydrogen fuel cells will take up more volume on cargo ships, which engenders an efficiency and opportunity cost of lost cargo. However, ships can be powered by hydrogen with minor changes to fuel capacity, such as replacing 5 percent of cargo space with hydrogen fuel.

BARRIERS TO IMPLEMENTING HYDROGEN ECONOMY

There are several barriers associated with implementing a clean hydrogen economy. Let us look at what those barriers are:

i. Green hydrogen's **high production costs** constitute the main barrier to the development of a clean hydrogen global market. In the energy market, hydrogen is indeed subject to market demand preferences and competition from competing for energy sources. Currently, green hydrogen production costs are still too elevated to economically compete with other energy sources or with hydrogen produced from fossil fuels, thus impeding a global clean hydrogen market to develop.

- Hydrogen is expensive not only to produce, but also to transport, store, and deliver to end-users. Building of huge infrastructure and the need for cross-border cooperation is required. Hydrogen has indeed a low energy density, which makes it more difficult to store and transport than fossil fuels, thus increasing its costs. For this reason, the research has focused on the possibility of converting hydrogen into hydrogen-based fuels and feedstocks such as ammonia, synthetic methane, and synthetic liquid fuels, which are easier to store and transport, and in some cases are directly used in energy applications. This process would reduce delivery costs, thanks to the use of the existing infrastructure. However, many of the technology pathways to produce these hydrogen-based fuels and feedstocks are still not fully operational and can require the use of carbon, resulting in further costs and environmental damages.

Nowadays, hydrogen is usually produced and consumed on-site, with relatively low costs. Building a global hydrogen market would thus require huge investments in infrastructure development, such as pipeline and delivery networks. Moreover, a well-functioning handling value chain would require a range of technologies, able to store and transport hydrogen in the most effective and cheaper way.

iii. Hydrogen also encounters **efficiency losses**, which further contribute to raise its cost, making green hydrogen less competitive than other energy sources. According to the International Energy Agency (2019), after converting electricity to hydrogen, shipping it and storing it, then converting it back to electricity in a fuel cell, the delivered energy can be below 30% of what was in the initial electricity input.

- For this reason, in many cases, it appears more convenient to directly use electricity, instead of converting it into hydrogen and then reconverting it into electricity. Of course, hydrogen's energy efficiency also highly depends on its various applications, making it more convenient in certain sectors than others. Taking into account these considerations, reducing energy losses is crucial to reduce hydrogen supply cost.

iv. The **lack of an existing clean hydrogen value chain** represents one of the major obstacles to overcome for the development of a low-carbon hydrogen economy. Nowadays, hydrogen value chains are indeed mainly dominated by fossil fuels, with only a few pilot projects on low-carbon hydrogen. A global clean hydrogen market would thus require creating completely new value chains. Specifically, the major challenge lies on the choice over which pathway to take, since hydrogen can follow different paths in the supply, handling, and demand chains. Hydrogen can indeed be produced, transported and distributed in different ways, and its demand can come from different sectors. The most competitive outcome will depend on the technologies and infrastructures involved, and it will vary in different regions and applications.

v. **Limited scope for the use of Hydrogen in the current market** is yet another barrier. Today, hydrogen is mostly used in certain industrial sectors, namely oil refining, chemicals and iron and steel. In all of these sectors, hydrogen is supplied using fossil fuels, with a high level of CO2 emissions. In order to meet climate goals, these sectors should transition towards the use of low-carbon hydrogen which is however linked to elevated costs. Nonetheless, a future global hydrogen market should look beyond the existing industrial applications, expanding to other sectors thanks to hydrogen's high versatility. For instance, clean hydrogen offers promising potential in the buildings, transport, and power sectors, where it plays an important role in decarbonisation policy goals.

Hydrogen also represents a viable solution to reduce carbon emissions in aviation and shipping, whose low-carbon fuel alternatives are constrained

vi. The **need for international standards and regulations** on hydrogen represents a major obstacle to the development of a global hydrogen market. Since hydrogen is an emerging market, there are still no international standards on its production and use, leading single countries to develop their own internal standards and regulations, or even unwritten and unclear rules. This lack of a common regulation limits the diffusion of hydrogen, restraining its potential.

HYDROGEN ECONOMY: INDIAN POSITION

As early as in 2003, National Hydrogen Energy Board was formed and in 2006 the Ministry of New and Renewable Energy laid out the National Hydrogen Energy Road Map identifying transport and power generation as two major green energy initiatives. India is participating in Mission Innovation Challenge for clean hydrogen and shares the objective to accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage and use of hydrogen at gigawatt scale. National Hydrogen Energy Mission (NHM) will draw up a road map for using hydrogen as an energy source.

- The initiative has the potential of transforming transportation. NHM initiative will capitalise on one of the most abundant elements on earth (Hydrogen) for a cleaner alternative fuel option. The Government of India has allotted Rs 25 crore in the Union Budget 2021–22 for the research and development in hydrogen energy and intends to produce three-fourths of its hydrogen from renewable resources by 2050.

GCC (Gulf Cooperation Council)

The GCC (Gulf Cooperation Council) countries have invested heavily in hydrogen energy and are looking at it as the holy grail to a cleaner future. This is an opportune time for India and the GCC countries to strengthen partnership in R&D, production, storage, and transportation of hydrogen energy. India should look at enhancing hydrogen cooperation with GCC countries, especially the front runners, i.e., Saudi Arabia, the UAE and Oman.

AIM: HYDROGEN ECONOMY IN INDIA

1. Focus on generation of hydrogen from green power resources.
2. To link India's growing renewable capacity with the hydrogen economy. India's ambitious goal of 175 GW by 2022 got an impetus in the 2021-22 budget which allocated Rs. 1500 crore for renewable energy development and NHM.
3. The usage of hydrogen will not only help India in achieving its emission goals under the Paris Agreement but will also reduce import dependency on fossil fuels.
4. The government plans to implement the Green Hydrogen Consumption Obligation (GHCO) in fertilizer production and petroleum refining, similar to what was done with renewable purchase obligations (RPO). RPOs require electricity distribution companies to buy a fixed amount of renewable energy to cut reliance on fossil fuels. India's total hydrogen demand is expected to touch 11.7 million tonnes (mt) by 2029-30 from the current 6.7 mt.

WHAT ARE THE RECENT STEPS TAKEN BY INDIA IN INTRODUCING HYDROGEN FUEL IN THE TRANSPORT SECTOR?

- A hydrogen fuel cell bus has been launched in India by Tata Motors in collaboration with the Indian Space Research Organisation (ISRO) and Indian Oil Corporation (IOCL). Further, Hyundai also seeks to launch its first fuel cell SUV in India and plans to build the required infrastructure for it in and around the Delhi-NCR area. It has further shown interest in introducing hydrogen-powered trucks in India if the government demonstrates a positive stance in the promotion of hydrogen.

- Recently, the Ministry of Road Transport and Highways has notified amendments to the Central Motor Vehicles Rules, 2020 wherein it has issued standards of safety evaluation of the vehicles propelled by hydrogen fuel cells. The suppliers and manufacturers of such hydrogen fuel cells vehicles now have standards available to test the vehicles, which are at par with the international standards.

- India's heavy-duty transport market is set to rapidly expand and with it, associated CO2 emissions. According to the IEA, oil demand from heavy-duty road transport in India will nearly treble by 2040 (IEA, 2017). India will see the greatest increase in heavy-duty road transport of any region in the world, presenting both a huge challenge and an opportunity. Zero-carbon trucks, using hydrogen fuel cells are already technically feasible, although the cost and carbon intensity are currently greater than that of diesel equivalents.

STRATEGIES ADOPTED BY OTHER NATIONS

Several countries such as Japan, the US, UK etc have already taken various measures in adopting hydrogen strategies. To become technology leaders, these countries have implemented strong supply-push policies for priority technologies, in part by ensuring adequate and appropriate financing across the innovation chain, with both public and private funding playing an important role. In parallel, they have also introduced policies to pull technologies towards deployment and diffusion, including subsidies for novel technologies or standards and regulations, which have limited the deployment of fossil fuel equivalents.

FUTURE OF INDIA

The future of India in terms of implementing a successful hydrogen economy looks bright however, we still have a very long way to go. We have been toying with the idea of hydrogen economy for almost 2 decades, however, not much has been done until now. The need for action is at its peak with climate crisis entering into an alarming state. India has largely lost out on the benefits of manufacturing these technologies, which include high value-added employment, increased tax return and the ability to innovate on existing manufacturing processes to develop the next generation of renewable technologies.

To avoid missing out on the future benefits of the energy transition, India needs to be proactive in creating a productive innovation ecosystem for the development, deployment and diffusion of technologies. There are however several positive moves on the part of the government to improve research and development on the feasibility of introducing a hydrogen economy but, current activity is still an order of magnitude below where it needs to fully take advantage of a transition to hydrogen technologies, with manufacturing centred in India. In terms of the investment requirements, if India is to deploy green hydrogen as a clean energy solution for key sectors, including transport, industry and power, by 2050, this would require significant investment in electrolysers.

THANK YOU…

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