Hydrogen as a Viable Fuel for the Future of Transportation Sector

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ABSTRACT: Transportation play a key role in human life as it make people life easy and simple during travel form one place to another in minimal time as compared to ancient time. Modes of transportation should be clean, cost-effective, and ecologically outgoing. Hydrogen may be a good synthetic energy supply for the automotive industry since it has a strong gravimetric energy content. Nonetheless, obtaining commercially feasible output through renewable energy sources, on-board infrastructure to attain the required driving range, the use of lengthy energy conversion devices, and the development of distribution systems remain major challenges. This paper presents recent advancement in the manufacturing, transportation, distribution, and transmission of hydrogen, as well as environment and safety implications of using such an energy source. Furthermore, this paper argues that non-renewable resources currently dominate hydrogen production processes; nevertheless, in order to create hydrogen production entirely viable, it is necessary to increase and promote the utilization of renewable sources.

KEYWORDS: Electricity, Energy, Pollution, Production, Transportation.

INTRODUCTION

Owing to the abundant supply and simplicity of use, water vapor as well as liquid fossil fuels meet a considerable portion of world energy demand including petroleum oil accounting for more about one quarter of the global overall energy mix and therefore more over 92 percent of automotive energy requirements. Global demand for fossil fuels, on the other hand, is predicted to increase rapidly before declining [1]. While some energy experts say that road vehicles consume nearly half of a world's oil production, the International Energy Agency (IEA) estimates that road transport accounted for roughly 77 percent of the world transport oil demand in 2010, with biofuel, petrol, and electricity inside the transport sector accounting for 39 percent, 3 percent, and 1 percent, respectively.

Vehicles are increasingly growing, causing numerous issues such as congestion as well as global warming. Vehicles use about 18 percent of basic oil and contribute about 17 percent of the world CO_2 emissions. Air pollution, global warming, road congestion, resource usage, disasters, and congestion are also big issues in the surrounding neighborhood. Urban air pollution, primarily from vehicles, seems to have become a major problem for city air quality, particularly in the world's fast expanding metropolitan areas. The use of fossil fuels raises CO_2 levels in the atmosphere by 31012 kg per year, which contributes significantly to global warming.

The only issue would be that sea water absorbs a substantial portion of CO_2. Per year, around 21,012 kg Carbon dissolves in salt water. The solubility for carbon dioxide reduces by about 3% per K when the water temperature rises. As the temperature of the ocean rises, the carbon dioxide solubilization equilibrium changes into the atmosphere, resulting in a drop in CO_2 flux directly into the sea and, as a consequence, a spike in greenhouse gas levels in the environment.

There is an immediate need to identify alternatives for energy consumption in cars in order to address the challenges of rising fuel requirements and containing pollutants associated with road transport. Vegetable oils which include triglycerides, are used to make bio-diesel, a petroleum-free alternative to diesel. Attempts to manufacture liquid biofuels using vegetable oils as well as Jatropha curcas L (JCL) have piqued the attention of businessmen, politicians, and renewable energy technology plant developers all over the world. This crop's oil could be easily turned into liquid biofuel. The press cake could also be used as fertilizer, and waste material can indeed be digested to produce biogas.

CNG seems to be another car gasoline option that is used in a variety of countries. The CO_2 emissions are reduced the most with CNG from engines, besides hydrogen and power, of any option, with a reduction of 20-25 percent. Hydrogen can be combined with CNG to reduce pollution even more. Alternatives to gasoline and diesel all have limitations and disadvantages. There is no other fuel that is meant to be as easy to make and handle as gasoline and diesel. While high conversion efficiencies can be achieved in the production of gasoline and diesel from crude oil, any replacement fuel will typically need higher conversion drops. Furthermore, since gaseous fuels are hard to handle, modern distribution and refuelling infrastructure is needed. Modern drivetrain components, like fuel tanks, motors, and batteries, are needed for energy carriers like hydrogen and electricity.

Hydrogen appears to be the most viable option for transportation applications across three counts: elimination of greenhouse gas (GHG) emissions, urban air pollution reduction and energy quality. Since hydrogen emits no emissions, it is a great alternative to fossil fuels, it eliminates all CO_2 and air pollutant pollution caused by transportation. This is also where fuel cells, with their higher conversion efficiencies than internal combustion engines, may have a big effect.

On a lengthy basis, in many nations hydrogen is viewed as a key green energy vector, and is primarily seen as a critical technology for meeting energy needs in the stationary electricity, transportation, manufacturing, and residential sectors. The following parts of this article include hydrogen applications, refining processes, resources as a fuel supply with protection and environmental implications, packaging, and distribution [2].

1. *Potential of Hydrogen:*

Hydrogen has the potential to limit greenhouse gas emissions from electricity generation, transportation, and heating. This is because no pollutants are created when electricity is generated by electrolysis, which involves using electricity to split oxygen and hydrogen. Today, a very well application of hydrogen is in transportation. Electric car owners are frequently concerned with their vehicle's range as well as the time required to refuel. Hydrogen-powered battery - electric vehicles, that have a bigger range, an even shorter refueling time, and need few to no modifications, escape these issues. In addition, hydrogen can be used as an alternative energy source in one's home. It could be used in combination with or instead of fossil fuels. It could be moved using the existing gas supply, eliminating the grid costs correlated with greater heat electrification. When shaped, hydrogen can be used as a medium and longer energy storage method. Proponents argue that excess renewable energy, like that created when the wind is blowing late at night, can be captured and stored by salt caverns and high-pressure tanks, and also that hydrogen produced using this electricity could also be deposited in high-pressure reservoirs or salt caverns (Figure 1).

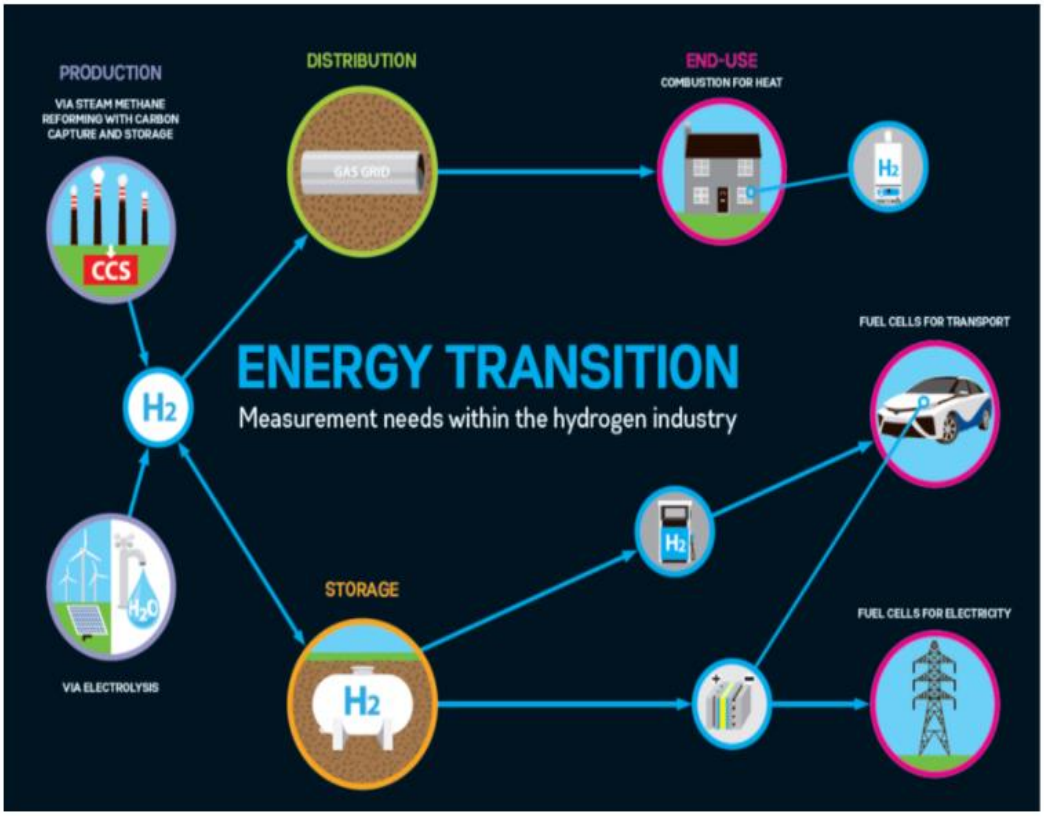

Figure 1: The energy transition of harnessed hydrogen. Hydrogen, once formed, may serve as both a short and long-term energy storage medium [World Economic Forum].

2. *Hydrogen Applications:*

The current literature reflects about hydrogen applications in a wide range of areas, including human life, manufacturing, aviation, and space travel, among others. Hydrogen is mainly utilized in petrochemical industry, ammonia or pesticide production, and metal processing for nickel, tungsten, copper, zinc, molybdenum, uranium, as well as lead. Hydrogen could be used as an energy in almost any application in which fossil fuels are being used, including automobiles, with immediate benefits in terms with lower emissions as well as a healthier environment. The following are some of the most popular uses for hydrogen today:

- Ammonia and other nitrogen-based fertilizers are synthesized.
- Desulfurization and refining.
- Hazardous waste hydrogenation.
- Food processing, ethanol, methanol, chemical plants, and dimethyl ether synthesis, Fischer-Tropsch method alternative energy synthesis
- Synthesis of gas to liquid.

C. L. McCarthy et al. also published a brief study on global hydrogen use for the manufacture of ammonia, chemicals, and photochemistry. Ammonia manufacture consumes 250 billion cubic meters (BCM) of hydrogen, accompanied by the manufacturing of other chemical materials, which consumes 65 BCM, as well as petrochemistry, it consumes 185 BCM, responsible for 50%, 13%, and 37% of total hydrogen consumption, respectively [3].

Hydrogen has a broad variety of possible energy applications, including non-polluting car propulsion, home and workplace heating, and aircraft fueling. On the one side, hydrogen's utilization in city buses and construction equipment are only two examples of mobility technologies that have advanced to demonstration standards. Hydrogen is a promising fuel that offers several advantages over conventional fuels. Nevertheless, widespread and functional usage would undoubtedly necessitate steps to ensure sustainable transport from the manufacturer to end-users, as well as additional service, fueling stations, and a slew of other novel ideas and technologies.

3. *Generation Transformation:*

The demand of electricity is continuously increasing across the globe day by day. Even if we become much more energy efficient, analysts predict that our energy consumption in 2050 will be 30-40% higher. Global electricity consumption has more than doubled in the last 30 years. The transition expected of how the energy is produce unparalleled. Renewables are becoming more affordable, and over $2 trillion has been invested globally over the last decade. Despite this, the percentage of our energy that comes from fossil sources has remained relatively constant. In 35 years, there has been no change in our dependency on fossil fuels. The percentage of our energy that comes from fossil sources has remained relatively constant (Figure 2).

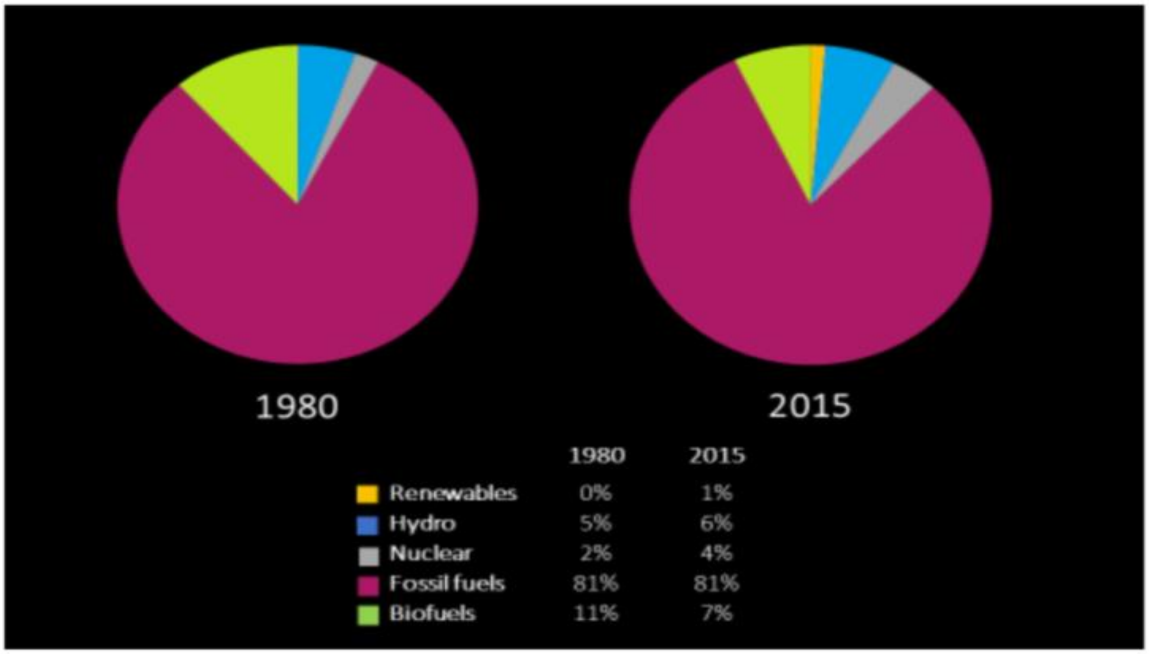

Figure 2: In 35 years, there has been no change in our dependency on fossil fuels. The percentage of our energy that comes from fossil sources has remained relatively constant [World Economic Forum].

Existing low-carbon technologies must be scaled up even faster; else, population growth is expected to outpace renewables spending, and fossil fuels would continue to dominate. Nevertheless, it is unrealistic to demand more from technologies that have already proved to be promising. Just three out of 26 low-carbon areas of study, such as solar photovoltaic (PV) and wind energy, power storage, as well as electric vehicles (EV), are progressed and commercially feasible, according to the IEA survey [4].

It's doubtful that we'll be able to get more out of these three technological fields than what's actually planned. Solar PV and nearshore wind should be used in conjunction with power storage or other forms of power generation due to their intermittent nature. High-energy-density electrodes, that are used in either storage and electric vehicles, are posing concerns about whether the manufactured goods used to produce them would be sufficient to meet demand. According to Bloomberg New Energy Finance (BNEF), graphite consumption is estimated to increase from 13,000 tonnes a year in 2015 to 852,000 tonnes a year in 2030, while lithium, cobalt, and manganese consumption will increase by more than 100 times. This has put a strain on supply chains and prices, as well as the workers in these mines, who are frequently employed in appalling conditions (Figure 3).

Figure 3: The market growth of EV batteries has resulted in an increase in the demand of their raw materials [World Economic Forum].

4. *Hydrogen as a Competent Carriage Fuel:*

Hydrogen has received a lot of press in recent times as a favored energy carrier, specifically for automotive industries, for a range of factors: it's a clean fuel that emits almost nothing besides water at various stages of usage. It can be made from any energy source, with widely accessible renewable energy being one of the most appealing, and it has a high-power density. Hydrogen is a non-toxic, colorless, and odorless gas. The most abundant ingredient in the system, hydrogen has the highest basic energy content of any traditional fuel. Hydrogen has a higher energy yield than hydrocarbon fuels, at 120 MJ/kg, or 2.75 times that of gasoline, but its density is much lower. Hydrogen has the strength of containing 2.6 times more energy per unit mass as compared to crude, giving it a greater heating capacity than gasoline. Because of the lower volumetric storage capacity it takes almost 4-times as much fuel to store the same amount of energy. Even though hydrogen is not considerably different from certain gaseous fuels, hydrogen is frequently used as a substitute in internal combustion (IC) automobiles because it allows car makers to utilize the same engine production facilities. In fact, a mixture of hydrogen as well as ethanol is frequently used as a green fuel replacement in carbureted spark ignition engines [5].

A fuel cell functions similarly to an electric battery in that it produces current by converting chemical energies to electrical energy by passing charged hydrogen ions across an electrode surface. They reconstitute with oxygen to provide water, which seems to be a fuel cell's sole waste, as well as hot air. Fuel cells surpass internal combustion engine innovation, which converts fuel to kinetic energy with a rate of almost 25%, despite being less efficient than electric batteries. A fuel cell could produce electricity with up to 60 percent efficiency by combining hydrogen with air (Figure 4).

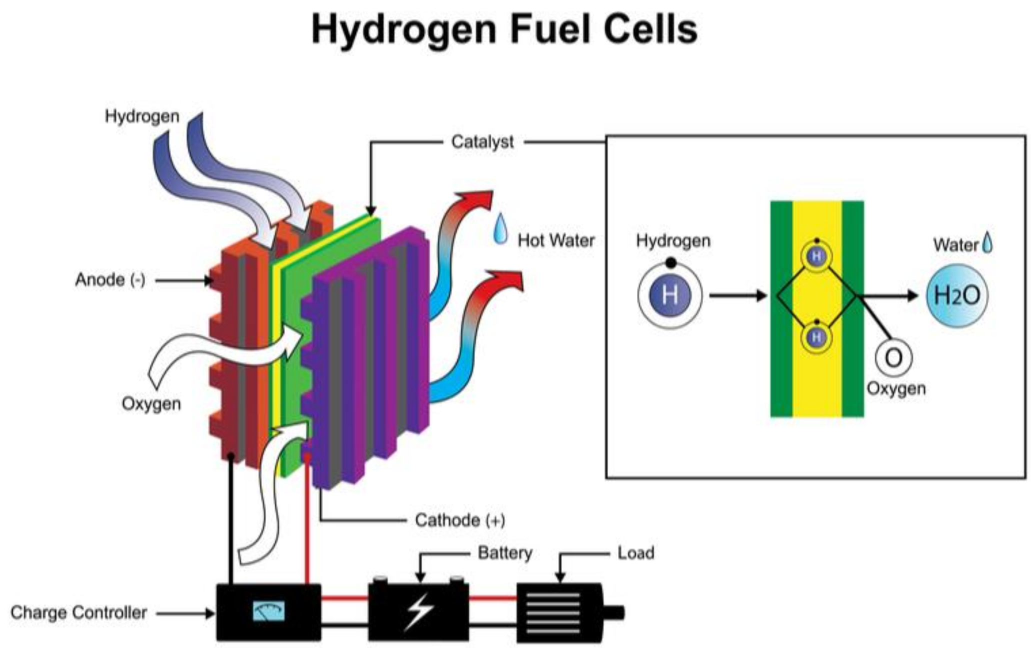

Figure 4: Illustrates the Hydrogen fuel cells. A fuel cell functions similarly to an electric battery in that it produces current by converting chemical energies to electrical energy by passing charged hydrogen ions across an electrode surface [Power Technology].

5. *Transport and Delivery of Hydrogen:*

Hydrogen delivery is a critical component of a long-term hydrogen economy. It necessitates the construction of infrastructure to carry hydrogen from its source. Compressed tube trailers, compressed gas pipes and cryogenic liquid trucks are three options for hydrogen delivery. During different stages of the hydrogen fuel market's growth, a mixture of these three choices could be used (i) during the initial introductory phase, tubes should be used because demand is likely to be low and it avoids boiling issue related to storage of liquid hydrogen (ii) cryogenic oil tankers, that can carry more quantity than tube trailers, were suitable for satisfying the requirements of expanding markets, and (iii) as requirement for hydrogen increases, pipelines can be conveniently laid to carry hydrogen to strong market areas, necessitating the development of more hydrogen generation capacities.

Scale, number of stations, and supply distance all have a substantial effect on distribution costs. Transporting pressurized or liquid hydrogen, on the other hand, is impractical due to the low density of gaseous hydrogen. Pipeline transportation has coverage and degradation limitations due to its simplicity. Hydrogen pipes are supposed to resist issues like hydrogen thermal shock and corrosion because hydrogen can quickly flow into the crystalline structure of many of these metals. Regional and market requirements will decide the most cost-effective delivery mode.

6. *Future Aspects:*

The idea of using hydrogen as a viable fuel has attracted substantial attention in recent years, comprised of a diverse variety of academic scholars, policymakers, industry, and civil society organizations, advocating hydrogen as a way of providing a clean and safe energy infrastructure. To transition from a carbon-based energy system to a hydrogen-based economy, three major technological hurdles must be overcome. To continue, in order to compete with other alternatives, the cost of efficient and affordable hydrogen refining and transmission must be dramatically reduced.

The key potential prospects for hydrogen transportation and supply are primarily dictated by four factors: projected hydrogen costs, production degree of numerous hydrogen-based methodologies, possible longstanding greenhouse gas caps, and alternative energy system costs. Hydrogen has the ability to be a long-term clean energy source with many social, technical, and environmental advantages. In the long term, It has the ability to minimize reliance on fossil fuels, as well as to minimize and control emissions in the automotive industry. Understanding of social as well as cultural dynamics is important in understanding the idea of socio-technical processes with each modern technological change. Present trends and knowledge of motorized speed and range cannot be quickly exceeded by upcoming modern modes of transportation in society.

With technical advancements, socio-cultural obstacles can be resolved by economic means. Such tactics like campaigning may be used as part of initiatives to encourage a particular technical advancement. Barriers found in daily activities and rituals, social expectations and beliefs, aesthetic tastes, and so on must be recognized and understood. Current energy system design and social activities require some reforms, as well as appropriate political-administrative assistance in the form of public finance, expenditure, and legislation.

The most cost-effective and reliable storage mechanism is still being researched. The transportation and delivery of hydrogen is the second most significant problem. The three potential hydrogen distribution pathways currently used for various uses are sealed tube trailers, cryogenic liquid vans, and compressed diesel.

Politico-economic policy and finance was to blame for the present state of oil and natural gas. As a result, repeating the identical concept in coming years for hydrogen would require a significant effort, and politicians from various countries will need to align their future energy demands in order to extend hydrogen's use as a transportation resource. Economic and regulatory initiatives, as well as increased global support for research and commercialization efforts, would eventually pave the way for the first steps toward a hydrogen economy, which would provide nations with energy security and people with a clean and healthy environment.

CONCLUSION

Hydrogen is the most effective energy carrier for automobiles. It has the same adaptability as electricity and can be derived from both natural and exhaustible resources. While exhaustible resources are utilized extensively in the production of hydrogen, it is vital from a sustainability perspective. In modern environment, hydrogen is indeed an essential biofuel or energy supply, with uses such as ammonia refining, radioactive waste hydrogenation, petroleum refinery desulphurization. Transportation is one of the most critical potential uses for automobiles as well as fuel technology, since it has a range of benefits over widely used systems based on conventional fuels, such as better energy conversion efficiencies and, in the case of fuel cells, almost zero emissions. The market is very familiar with hydrogen, which contributes to the belief that it is a safer product. It must, however, be thoroughly checked until it can be used by the general public.

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