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HYDROGEN PRODUCTION FROM RENEWABLE SOURCES AND NON RENEWABLE RESOURCES

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ABSTRACT

Hydrogen production plays a very important role in the development of hydrogen economy. One of the promising hydrogen production approaches is conversion from biomass, which is abundant, clean and renewable. Alternative thermochemical (pyrolysis and gasification) and biological (biophotolysis, water–gas shift reaction and fermentation) processes can be practically applied to produce hydrogen. This paper gives an overview of these technologies for hydrogen production from biomass. The future development will also be addressed.

KEYWORDS: Hydrogen Production, Hydrogen Economy, Thermochemical Processes, Biological Processes.

INTRODUCTION

Hydrogen is the simplest element in periodic table and its atomic no is 1. It is found in gaseous state mostly. Rising greenhouse gas emissions in our environment become a critical and concerning point for population. Due to technological advancement, population and economic growth have asked for reliance on fossil fuels, a major source of greenhouse gas emission.[1,2] World's need total energy supply was 12,717 MTOEA in 2010. In which approx. 80 % obtained from fossil fuel. The World's wide CO_2emissions were 30,326Mt in 2010.[3] This is because of using fossil fuel. There for we need to switch to a CO_2neutral energy carrier so that reduce the CO_2emission. Continuously increasing world population demand more energy as a result, a growth in energy generation capacity will be needed. When we use hydrogen as fuels, we reduce the emissions and dependence on imported oil. Hydrogen is the most simplest element in Universe it will present combinations with other elements like oxygen, nitrogen, carbon. When we use hydrogen as a fuel no CO_2emissions takes place so we can say that hydrogen is very clean in terms of emissions at the point of use.[4] The vision 2050 of the world energy outlook 2020 to reach net zero emissions necessities clean energy-based sustainable development and provide guidelines on measure required to be implemented in the next decade to meet net zero emissions. Hydrogen is not only considered a gas but also act as an eco-friendly fuel. When we try to extract energy considered a gas but also act as an eco-friendly fuel. When we try to extract energy from hydrogen, we get only water and heat as by -product and not greenhouse gas.

Emissions.[5-7] Today's 95 million tons of hydrogen produced in which 76% obtained from natural gas and 22% from coal.[8] We will use hydrogen as a fuel source in the future.[9] More than 85% of hydrogen comes from fossil fuel which is major contributor to environmental pollution. In addition, other technologies including renewable sources to produce hydrogen have improved significantly.[10] Few challenges and difficulties persist over commercial application of hydrogen production from these resources. However growing research in the sustainable production of hydrogen has shown positive sign in becoming more commercially viable technology.[11] This paper explores of hydrogen production from renewable and non-renewable sources. The technology which includes the use of fossil fuel to produce the most hydrogen fuel currently includes partial oxidation, steam reforming and gasification. But the problem with this technology is that it produces excessive amount of carbon emission. So, we prefer hydrogen production from renewable resources.[12] The total chain of hydrogen economy depends on several factor such as efficient production, long term storage, implementing safety standards, and mobility application.[13] Hydrogen is also considered as the future fuel source in the transportation and energy sector.[14] Currently carbon-based fuel supply 85% of the entire world's energy demand. Approximately 36 billion tons of CO_2 are emitted into the atmosphere every year to meet the energy demand. Of these emission over 90% comes from fossil fuel[15], and it is expected to further increase in the coming years, as shown in Figure 1. Besides the strong environmental impacts, fossil fuels are ever-dwindling supplies, and oil prices wildly fluctuate, impacting profits for industries that produce and use oil and the ability of consumers to purchase goods and services.[16] Energy consumption and carbon emissions represent two crucial elements of the European Union energy strategy.[17] Different targets have been set up to ensure a reduction of both energy consumption and carbon emissions. In this sense, thenet European Union binding agreement for energy efficiency target (primary energy consumption) focuses on a 30% reduction in 2030 compared to the 1990 level.[18]

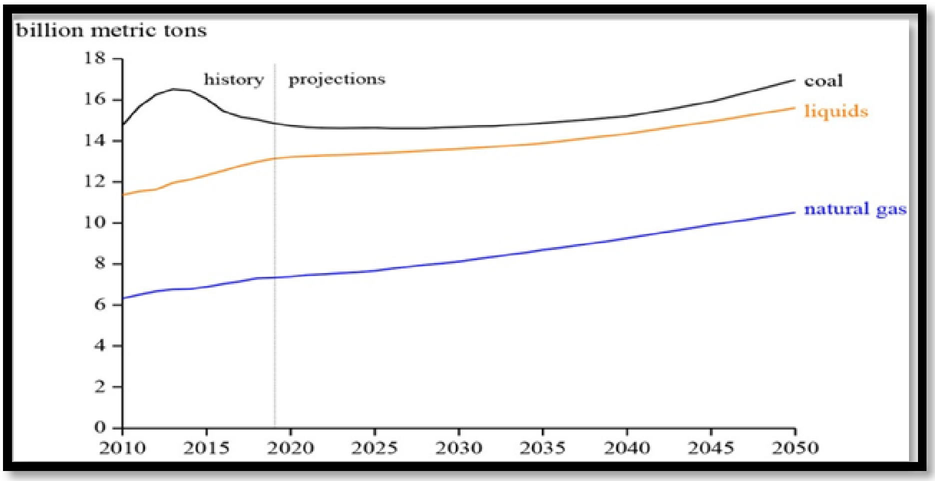

Figure 1: Energy related carbon dioxide emission [ref no.22].

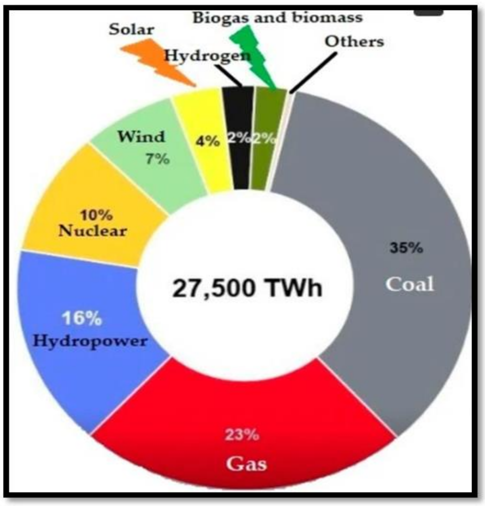

Figure 2: Global share of energy sources [Ref no 23].

Figure 2 depicted the proportion of the world's energy supply. A massive 35% of the world's energy supply comes from coal, followed by a 23% share from gas, 16 % from hydropower and 10% from nuclear. Renewable energy contributes around 13%, which include 7% from wind energy, 4% from solar, around 2% from hydrogen and rest from biomass an. Annual CO2 emissions from different types of fuel are shown below **figures 3.**

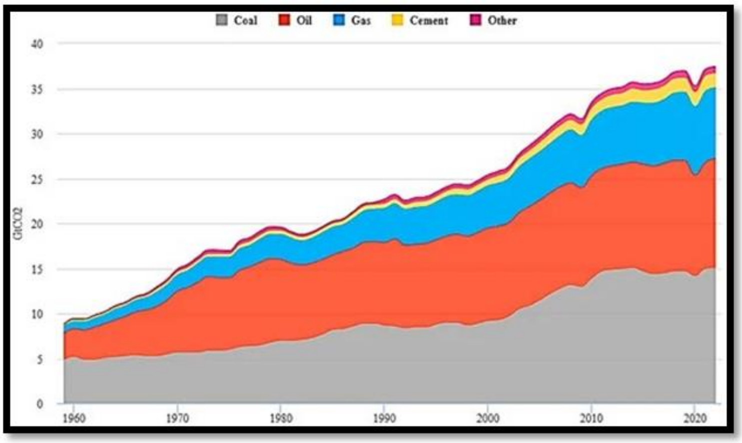

Figure 3: Annual CO_2 emission from different types of fuel [Ref no 23].

Nevertheless, the immediate effects of the COVID-19 pandemic on the energy system showed falls in 2020 of 5% in the global energy demand, 7% in energy-related CO2 emissions, and 18% in energy investment. Renewable energies, especially those in the power sector, have been less affected by the pandemic when compared to other fuels.9 The World Energy Outlook 2020 has included the new net-zero emissions by 2050 scenario, which extends the sustainable development scenario based on clean energy policies and includes the first detailed International Energy Agency (IEA) modeling, setting out what additional measures would be required over the next 10 years to put global CO2 emissions on track for net zero by 2050. In this regard, a power system with net-zero emissions requires careful long-term and integrated planning. The electricity sector will play a key role in the emission reduction efforts, but low-carbon fuels, such as hydrogen, are also needed.

Achieving this objective would mean an acceleration in the deployment of clean energy technologies.[19-22]

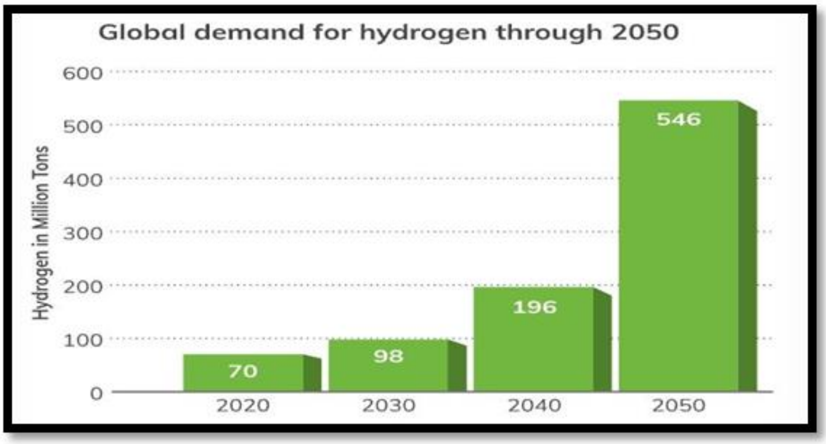

Figure 4: Global hydrogen production through 2050 [Ref no 25].

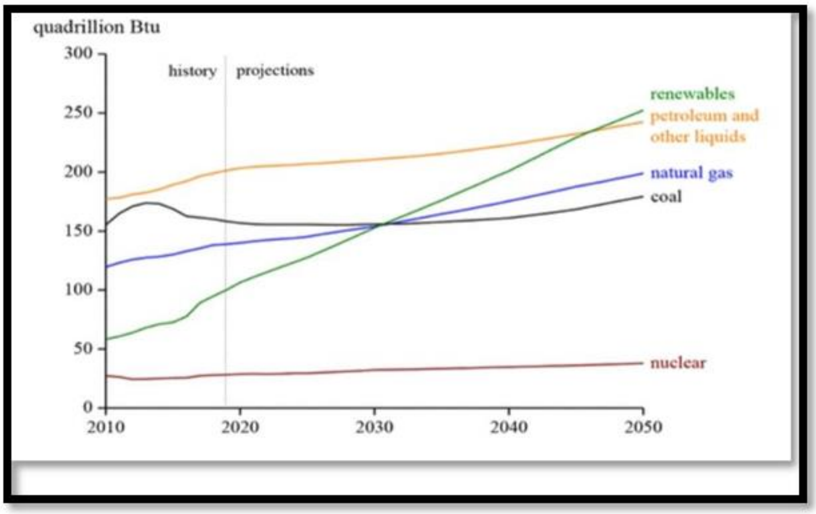

Figure 5: World primary energy consumption by energy source [Ref no 26].

Hydrogen production from renewable sources

A significant amount of hydrogen is derived from fossil fuels, and given the adverse environmental effects of these methods, the processes are considered unsustainable.[23] Furthermore, these resources are diminishing rapidly.[24] Renewable sources currently contribute a limited portion to hydrogen production. This has led recent research efforts to concentrate on creating environmentally friendly and pollution-free hydrogen from these sustainable sources.[25] Advancements in renewable such as biomass, solar, and wind energy have enabled the development of technologies for more efficient hydrogen production. Some methods of hydrogen production from renewable sources are briefly discussed like from wind and from solar energy.[26] Biomass stands out as a primary energy source, distinct from solar and wind energy. It holds a unique position among renewable resources, being convertible into liquid and gaseous fuels, serving as raw material for chemical production, including methanol, ethanol, and higher hydrocarbons. Some methods are precisely discussed here.[27] The use of biomass-based fuels not only lowers carbon footprints but also diminishes reliance on fossil fuels, positively affecting the agriculture sector and reducing solid municipal waste.[28] Amount of global biomass production is 1880 billion tones peryear, contributing to 14% of the world's total energy production.[29]

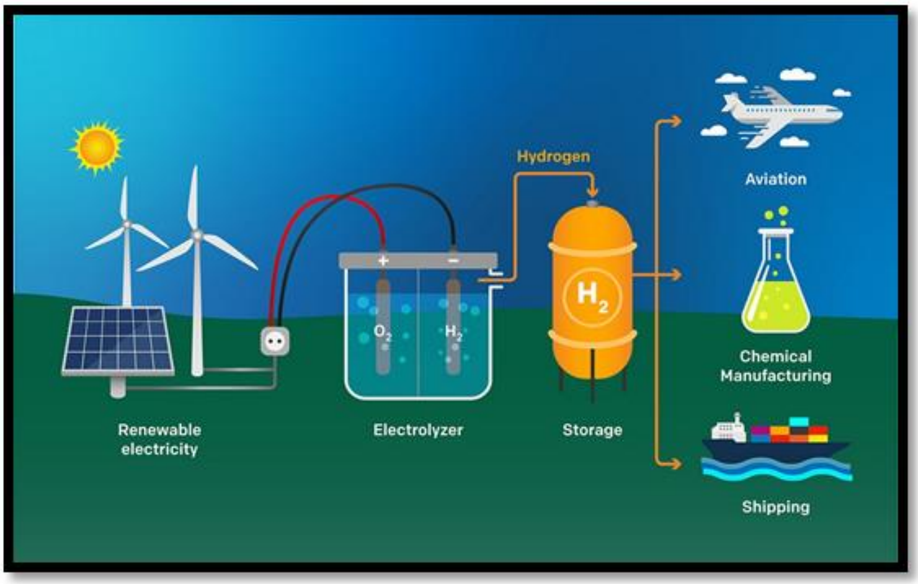

Figure 6: Hydrogen production from renewable energy [Ref.no. 29].

From wind energy

The growing demand for renewable energy, coupled with decreasing costs, is driving an increase in installed capacity for alternative sources. Countries globally are making comprehensive efforts to promote the use of renewable energy, with a particular focus on wind energy for sustainable electricity generation. This source is recognized as a reliable option for hybrid power systems, contributing to clean and reliable fuel for energy needs.[30] Currently, direct production of hydrogen from renewable sources is not feasible. An efficient hybrid system is required to extract hydrogen from wind energy.[31] This process is also suitable for eliminating GHG emissions which are associated with hydrogen production from fossil fuels sources.[32] The suggested setup includes a wind farm, an AC/DC converter (rectifier), a power controller, and an alkaline electrolyzer.[33] The energy conversion process involves generating electricity from a wind turbine. This electricity is then utilized in the electrolysis of water, where two electrodes extract hydrogen gas through an alkaline electrolysis system.[34] The electrolyzer consumes around 5-6 kWh/Nm3 of energy, and the rectifier efficiency, typically ranging from 85% to 95%, plays a crucial role in determining the amount of hydrogen produced in this process.[35] The efficiency of this process can be enhanced by adjusting the power produced by wind turbines.[33] The overall efficiency of the process is contingent on factors such as wind speed, turbine size, characteristics, and the system's location.[34] Among all hydrogen production pathways, wind energy is currently considered to have the lowest greenhouse gas (GHG) emissions.[36]

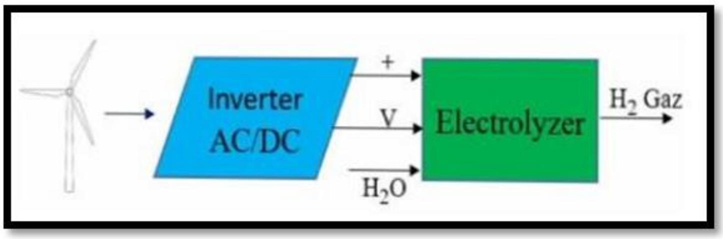

Figure 7: Hydrogen production process through wind energy [Ref no 34].

From solar energy

Solar energy is recognized as the renewable source with the highest potential to meet global energy demands in the future.[37] In recent years, as oil and natural gas prices fluctuated, the cost of renewable energy has experienced a substantial reduction.[38] The capacity of solar energy to generate low-cost electrical power holds the potential for the advancement of solar hydrogen as a clean alternative fuel.[39] The technologies for electricity production using solar power are primarily divided into two methods. The first is photovoltaic (PV) power generation, which produces electricity through the photoelectric effect, directly converting solar energy into electricity. The second is photothermal power generation, involving the use of arrays of mirrors to capture solar energy. This process generates heat through heat exchangers, which can then be utilized to power a steam turbine for electricity generation.[40] Commercially, water electrolysis using the two-step reduction process has been employed for hydrogen production. The hydrogen produced through electrolysis is clean Thermally dissociating water in the solar thermolysis process requires a high temperature exceeding 2900 K, and finding materials capable of withstanding such high temperatures is challenging.[42]

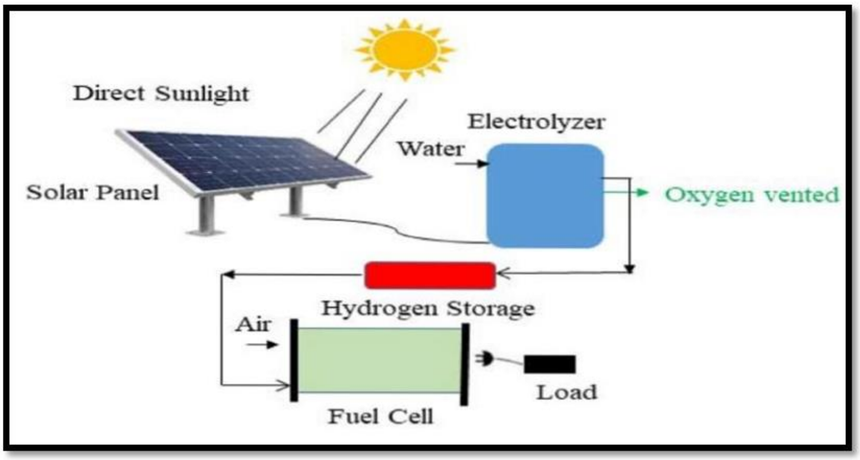

Figure 8: Hydrogen production process through solar panels [Ref no and devoid of any emissions.[41]

Non Renewable resources

Hydrogen production from non-renewable resources involves obtaining hydrogen through processes that rely on fossil fuels or other finite sources. Despite the environmental concerns associated with non-renewable methods, they currently dominate hydrogen production due to their established infrastructure and cost-effectiveness. Common non-renewable methods include steam methane reforming (SMR), which utilizes natural gas, and coal gasification. These methods release carbon emissions, contributing to environmental challenges. However, ongoing research aims to enhance efficiency and minimize environmental impacts in non-renewable hydrogen production.

From natural gas

Currently the natural gas is primary source for hydrogen production, constituting the most common method. Approximately three-quarters of today's hydrogen is derived from natural gas, with Steam Methane Reforming (SMR) being the prevalent method. In SMR, gas is initially cleaned, then mixed with steam in a reformer, resulting in the production of CO and H2 gas. The reactions in SMR occur at temperatures of 700-800°C and are reversible and largely endothermic. This process can yield higher amounts, reaching up to 100,000 tons in some cases. The steam reforming process follows specific reactions (equations (1) and (2)) to produce hydrogen.[42,43]

$$CH_4+H_2O \rightarrow CO + 3H_2 [1]$$

$$CO + H_2O \rightarrow CO_2+H_2 [2]$$

From coal

Hydrogen production from coal primarily involves coal gasification, a process where coal is reacted with steam and oxygen under high temperatures and pressures to produce a mixture of hydrogen, carbon monoxide, and other gases. This gas mixture, known as syngas, can then be further processed to extract hydrogen One drawback of this method is the release of carbon dioxide (CO2) during the gasification process, contributing to greenhouse gas emissions. To address environmental concerns, technologies such as carbon capture and storage (CCS) are being explored to capture and store the CO2 generated in coal-based hydrogen production.[45]

Figure 8: Coal-Based Hydrogen Production.

While coal-based hydrogen production is widely used, there is increasing interest in transitioning towards cleaner and more sustainable methods, such as electrolysis using renewable energy sources, to mitigate environmental impacts associated with fossil fuel-based hydrogen production.[46]

CONCLUSION

In comparison to non-renewable methods like steam method reforming and partial oxidation, hydrogen production from renewable sources, such as electrolysis powered by solar or wind energy and from biomass through biological method, is more environmentally friendly and sustainable because no CO2 emissions occur during the renewable method. As long as hydrogen is produced from sustainable sources, it has the potential to foster energy creation with the least amount of greenhouse gas emissions. Despite the commercialization of hydrogen production from traditional fossil fuels like coal and methane, the negative environmental effects of these fuels have caused researchers to redirect their focus to finding alternate energy sources. The synthesis of hydrogen from renewable sources has thus been the subject of contemporary research.

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