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ENVIRONMENTAL IMPACT OF HYDROGEN FUEL

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ABSTRACT

This paper explains the use of hydrogen as a clean energy fuel and critically analyses its environmental impact. Globally there has been an increased focus on climate change among governments, corporates and the general population in recent years. As a result, hydrogen has emerged as a viable alternative to fossil fuels, especially in the automobile sector. The analysis shows that although hydrogen fuel has zero greenhouse gas emissions, the current production of hydrogen fuel isn't exactly environmentally friendly. The different production processes release varying degrees of greenhouse gases and contribute towards global warming. In order to scale up the usage of hydrogen fuel in automobiles, there is a need for continued research in increasing the efficiency of green hydrogen and reducing the costs associated with its production. The goal of further research should be to minimise the negative impacts of producing hydrogen fuel to turn it into a viable and scalable fuel.

Keywords -*Hydrogen, Clean fuel, Environment Friendly*

[1] INTRODUCTION

Hydrogen fuel, also known as hydrogen energy, refers to the use of hydrogen gas as a source of energy for various applications. In automobiles, hydrogen fuel is utilised in fuel cells and produces only energy and water as a product and by-product. Thus, it is considered as a clean energy source. Hydrogen itself does not exist in usable form in nature and can be produced from different resources such as fossil fuels, natural gas, nuclear power, biomass, and renewable power. Hydrogen is an energy carrier that can be used to move, store, and deliver energy produced from other sources.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(g) + \text{energy}$$

[2] RELEVANCE

The first commercial use of hydrogen fuel cells came with the invention of the hydrogen-oxygen fuel cell by Francis Thomas Bacon in 1959 [1]. In the modern world, the population is majorly dependent on conventional energy sources to live a comfortable life, such as fossil fuels and other sources of energy, which are harmful to the environment and for the survival of human species in the long run. By comparison, Hydrogen fuel cells are cleaner, versatile, energy efficient and have many environmental benefits.

[3] Production of Hydrogen Fuel

Thermal Processes

Thermal Processes for hydrogen typically involve steam reforming, a high-temperature process in which steam reacts with a hydrocarbon fuel to produce hydrogen. Steam Methane Reforming is one of the current leading technologies for producing hydrogen in large quantities. In this process, we extract hydrogen from methane.[2]

Electrolytic Processes

Electrolytic processes are also used to produce hydrogen from water through the electrolysis process. Electrolysis takes place in an electrolyser.

Biological Processes

Biological processes use microbes such as bacteria and microalgae which can produce hydrogen through biological reactions. In this conversion, the microbes break down matter like biomass or wastewater to produce hydrogen. [3]

[4] Classification of Hydrogen Fuel

The use of hydrogen as a clean fuel is critiqued due to the production process of hydrogen. As Hydrogen does not exist in the atmosphere, there are different mechanisms for producing hydrogen fuel. Below is a classification of different variants of hydrogen fuel depending on the production process:

- Green Hydrogen- Hydrogen which is created by using renewable energy to run an electrolyser. Electrolysers use that energy to split a water molecule, separating the H_2 and the O.

- Grey Hydrogen- Hydrogen produced by steam reformation by using fossil fuels. 72% of the global hydrogen production is carried out by this method only.

- Blue Hydrogen- Hydrogen is produced by steam reforming like grey hydrogen, but the production units come equipped with carbon capture devices to reduce atmospheric methane or gas emission.

- Pink Hydrogen- This comes neither from renewable sources nor fossil fuel, hydrogen is produced via nuclear energy as its input. [4]

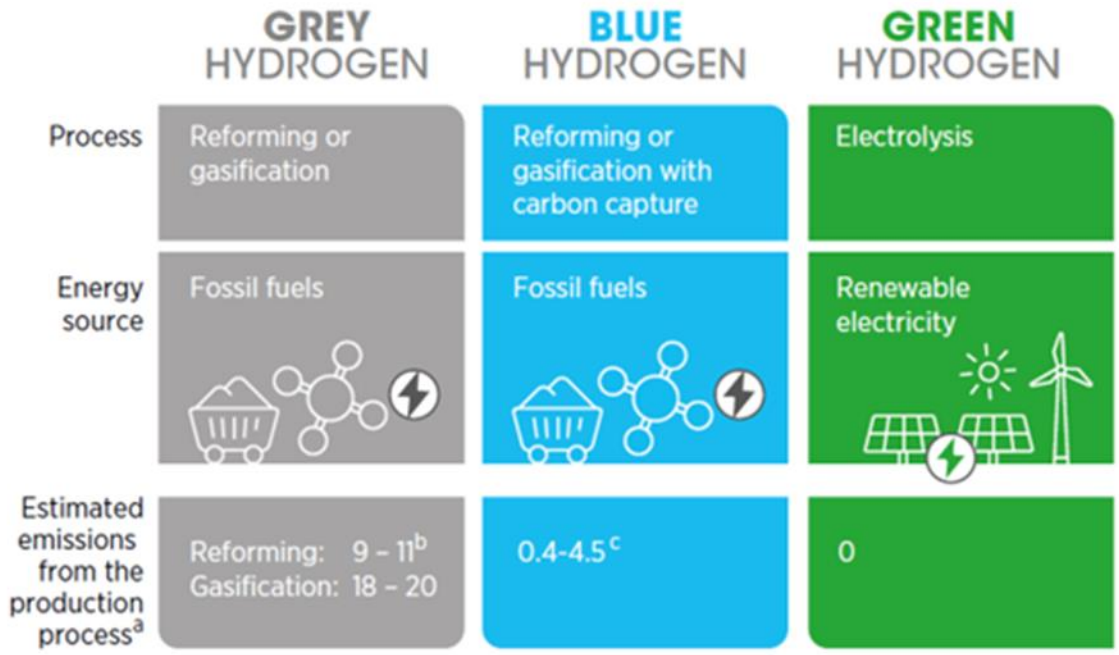

Figure 1: Grey, Blue and Green Hydrogen
Source: International Renewable Energy Agency

Figure 1 leads to the prima facie inference that blue and green hydrogen could be two potential clean energy sources. However, there are a few challenges with both technologies:

- Blue Hydrogen - During the production of blue hydrogen, despite deploying the carbon capture mechanism, greenhouse gas emission is high, due to fugitive methane (Howarth & Jacobson, 2021). Methane is a much stronger warming agent which causes 86 times the warming as compared to carbon dioxide over a 20-year period. Approximately 25% of the global warming in recent decades is caused due to methane. The exact amount of methane released during the production of blue hydrogen is unclear and requires further data collection and analysis. Therefore, with the risk of methane release, blue hydrogen remains a dubious choice as a clean energy source with potentially harmful environmental impact.[5]

- Green Hydrogen - Green hydrogen produced from solar and wind energy electricity is considered the true zero-emissions fuel. A crucial issue in scaling the production of green hydrogen is the cost of production which is significantly higher than other types of production mechanisms, since it is generated from renewable sources of energy.

The current hydrogen production in the world is 120 million tonnes per annum. Out of which 98.7% is produced from coal, natural gas or oil, without any carbon capture. Hence, in the current scenario, hydrogen fuel is not quite the ideal clean fuel that it is made out to be. [6]

[5] Other Challenges of Hydrogen Fuel

1) Lower Efficiency - For the automobile sector, translating hydrogen fuel cells into a viable and scalable alternative remains a challenge due to their much lower efficiency as compared to the electric battery. The below figure shows the energy losses at each stage while using hydrogen fuel cells versus the electric battery. With up to 50% of the losses occurring in the transformation of hydrogen to electricity stage, the hydrogen fuel cells exhibit a low-efficiency performance. Battery vehicles prove to be almost 3.2 times more energy efficient than fuel cell vehicles. [6]

2) Storage of Hydrogen as a fuel - Storing hydrogen in a compact way is a challenge because being a gas it requires high pressures and low temperatures to store. [7]

3) Highly flammable - Hydrogen gas is highly flammable and can easily cause explosions and fire if not handled properly. Hydrogen is also an odourless gas, which is so light that currently there are no known odorants that are light enough to diffuse with hydrogen and can be added to it to detect a leak. [8]

4) Costly - At present the cost of hydrogen is comparatively high from all other sources of energy. In order to make it usable the cost has to be minimised. Currently in India the cost of green hydrogen ranges from 300-500 rupees per kg. [9]

[6] SUMMARY

In this paper, we analyse Hydrogen fuel cells have the potential to become a clean energy alternative in place of fossil fuels. However, there is a need for more research towards developing low-cost hydrogen production mechanisms and higher efficiency fuel cells in order to replace fossil fuels and move towards a truly zero-emission environment friendly future. [10]

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