Green Hydrogen: Uncertain Future and is it Really Green? 2023

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Date: Jan1,.2023

The ongoing energy crisis running rampant in Europe has troubled the world and put much of the population in unease. However, this energy crisis comes with a slight silver lining when looking at the energy sector. Research on alternative energy sources, especially renewable ones, are at record highs, as Europe battles to survive cold winters and ensure that they can be self-reliant in terms of electricity. One major area that saw a significant increase in interest, is hydrogen-powered electricity production. As it stands, hydrogen, a highly combustible gas, is already being used for oil refining, ammonia, and steel production. Most of these current technologies rely on *grey hydrogen*, which is when fossil fuels are used in the production process [1]. In contrast, *green hydrogen* is produced by a process known as electrolysis, splitting water into its components, using electricity from renewable energy sources. This green hydrogen can then be used in a variety of industries, including petrochemical processes, fertiliser production, transportation vehicles, and the steel industry - which is currently under immense pressure from regulators for its considerable polluting effects [2]. While green hydrogen production, without a doubt, will be a very critical and vital player in the race to net-zero emissions, there are many obstacles relating to costs, demand, and timelines that must first be overcome to fully utilize its benefits.

Most of the hydrogen produced today is not green. The gas is colour-coded according to the way it is produced, says the EBRD's Christian Carraretto [3].
"The hydrogen that the world uses today is made from either coal or natural gas. This hydrogen is carbon-intensive, it's not a green fuel. It's called grey hydrogen if it comes from gas, while the hydrogen produced from coal is called black. Then there is blue hydrogen, an upgrade of the grey, where the CO2 emitted is captured upstream, so the system doesn't emit CO2 in the atmosphere."

The ongoing Russo-Ukrainian War has caused natural gas prices to skyrocket by more than 100%, according to Eurostat data in October 2022 [4]. These increases in natural gas prices, have made the use of hydrogen a much more realistic possibility and brought about the much-needed push for green hydrogen production. The higher non-renewable energy prices along with accelerated research and funding for hydrogen power has put the appeal for hydrogen at the highest it has ever been. In addition, the United Nations has a dedicated program, the Green Hydrogen Catapult (GHC), aimed at bringing down the cost of green hydrogen significantly by funding more electrolysis facilities around the world. Other countries like Japan have announced they will invest roughly $3 billion towards funding and research for the development of hydrogen use over the next decade [5]. All of these initiatives and programs will significantly help improve the usability of hydrogen around the globe and ensure its accessibility. Essentially, the more facilities and research that is dedicated towards green hydrogen technology, the further the price will decrease, making it a viable option for many countries to replace their existing non-renewable energy sources.

Further, Different fuels have different energy density levels, which can be measured in terms of equivalent energy released through combustion. Energy density is the amount of energy that can be released by a given mass or volume of fuel. It can be measured in terms of **gravimetric energy density** (per unit of mass) or **volumetric energy density** (per unit of volume). Gravimetric energy density is relevant when comparing the energy efficiency of fuels. At the same

time, volumetric energy density is relevant when comparing transportation modes as storage space (fuel tank) must be present to carry the fuel propelling a vehicle. The higher the energy density, the higher the fuel quality, which is inversely proportional to its chemical complexity. High-quality fuels are gases, while low-quality fuels are solids, with liquids in between. The highest energy density fuel is hydrogen, which is also the simplest chemical component in existence. [6]

Large energy focused companies have also begun to shift their attention to green hydrogen projects [7]. Based on an interview, conducted by SZC on Dec. 19th, 2022, with a Stress and Design Engineer who asked to remain anonymous at Wood PLC, a major player in the energy sector, they have just recently partnered with Gen2 Energy in Mosjoen, Norway [8]. This project will be the first large scale commercial hydrogen production plant in Norway, marking a massive milestone for the country's zero emissions goals. The partnership demonstrates how a recent shift in companies' perspectives are beginning to materialize.

While continued research and development for hydrogen technology go a long way, there are many obstacles that must be dealt with before advancements in feasibility are seen. The first, and most obvious, is the cost. Due to the complexity of hydrogen production facilities, limitations in transportation technologies, and supply chain issues plaguing the technology sector, green hydrogen has a very long way before costs are feasible for large scale commercialization. As it stands, there is very little financial incentive for companies to invest large amounts of money, that does not quickly provide adequate returns on investment. The uncertainty of hydrogen supply chain networks will also be a major challenge during the later phases of hydrogen adoption. Very little historical data is available to observe and study, which creates uncertainty and unreliability when it comes to distributing hydrogen fuel cells. In addition, regulations and laws regarding hydrogen production and distribution are not clearly defined to the point where mass scaling can be achieved. Finally, social factors, such as awareness, end-usability, safety, and accessibility are all issues that indirectly impact the demand for hydrogen power. All these factors present a current challenge for hydrogen adoption, clearly demonstrating the significant additional progress that must be made for mass production of green hydrogen.

Another challenge that poses a threat to the advancements of green hydrogen power, is the current limited supply. As mentioned earlier, green hydrogen requires electricity from renewable energy sources, thus making it difficult to produce in high quantities, especially in regions where renewable sources are scarce. This means that green hydrogen will have difficulty meeting the demand for electricity and will therefore lag behind other renewable sources. Recent technologies include small portable electrolysers that can extend the reach of hydrogen production in remote areas. Similar future advancements may further boost hydrogen accessibility. [9]

While hydrogen production still has many challenges and disadvantages that must be dealt with, there are numerous advantages to its adoption that will greatly help towards net-zero emissions goals. The first and foremost, is the environmental impact to produce green hydrogen. As mentioned earlier, the electricity required to produce the hydrogen must come from renewable sources. This means the drive towards hydrogen power will also help accelerate the use of renewable energy sources, such was solar power, wind, and hydroelectricity. This green hydrogen produced from the renewable energy sources can then be stored and used to power numerous technologies such as cargo ships, aircrafts, and large transportation vehicles. Essentially hydrogen fuel cells can act as batteries while having the benefit of being much lighter in comparison. This means that hydrogen can be stored and used in areas where renewable energy sources are not feasible due to geological constraints and limitations. Finally, the versatility of hydrogen is also very appealing. Much like natural gas, hydrogen can be used to heat homes, power furnaces, and industrial equipment. Hydrogen can also be used to generate electricity, much like any non-renewable energy source. All these benefits to hydrogen adoption demonstrate the potential hydrogen power, especially in carbon intensive applications and hard-to-decarbonise industries, such as steel production, heavy transportation (trains & large trucks), and maritime trade.

Another example of green hydrogen innovation and practicality is demonstrated by the company dynaCERT, which is a Canadian-based major player in the green hydrogen sector, providing hydrogen solutions and electrolysers to the heavy transportation industry. SZC conducted an interview with Ed Cordeiro, director of sales at dynaCERT on Dec 27th, 2022, to further explore the potential of the technology. Mr. Cordeiro said they are working heavily to bring small electrolysers to trucks by supplementing a standard diesel engine with hydrogen power [10]. Essentially, electrolysers are outfitted to diesel engines to reduce their fuel consumptions by up to 10-15% and 45% in CO emissions, among other benefits [11]. This type of technology is setting up the transition to full hydrogen powered vehicles and essentially providing hydrogen-hybrid engines. Mr. Cordeiro said his company is not only minimizing the environmental impact due to diesel engines, but also enhancing the market's education on such products and what the hydrogen future can look like. He also mentioned that it may take upwards of 8-10 years before full hydrogen powered trucks can be readily available, and during the meantime, dynaCERT's work will be a crucial step in improving the interest in hydrogen.

An additional topic of great interest that is often overlooked, is the life cycle cost. This concept considers the entire cost of a product, beginning with its production, storage, and transportation. Environmental and social impacts are also factors that come into consideration when dealing with the full cost of a product. When it comes to fossil fuels and non-renewable energy sources, environmental and social costs are often neglected, which are in fact significant. The prices we see in our day-to-day lives do not include the cost to the environment and the atmospheric pollution. This leads to the belief that non-renewable energy sources are cheaper that they truly are. Hydrogen and other clean energy sources, however, attempt to fully capture the cost of the environmental impact due to the nature of the zero emissions of the fuel. In this case, hydrogen facilities require much more capital costs and increased complexity to realize those environmental costs. Essentially, renewable energy sources are successful at effectively converting the 'unseen' environmental costs into realized capital costs, which are in turn reflected in the price of the product. This is largely the reason why renewable energy sources are higher in price compared to its non-renewable counterparts. In order for decarbonization to effectively take place, users must have an accurate understanding of fuel costs that includes all the external factors that go into producing that energy source.

While the production and storage of hydrogen have the potential to store excess renewable electric power over long periods of time, the process is far less efficient than other storage technologies, according to Arjun Flora, director of energy finance studies for Europe at the Institute for Energy Economics and Financial Analysis, or IEEFA. [12]

Overall, due to rising prices in natural gas and other supply chain issues relating to fossil fuels, renewable energy sources are becoming more appealing, and with advancements in technology, the feasibility of these new technologies are also improving. Hydrogen power produced from renewable energy sources is gradually getting more attention, with research across the globe accelerating. Many countries and companies are beginning to embrace green hydrogen power, due to its many benefits to the environment and sustainability considerations. However, there are still many challenges and difficulties this new sector must strive to overcome, such as cost, reliability, and social awareness. Most of these issues can be mitigated with increased funding, research, and technological innovation. More and more infrastructure and new projects around the globe are being erected, which spells very good news for hydrogen production. Moreover, hydrogen fuel cells have also been proven to have further advantages, such as sustainability, storage capabilities, and its versatility. All these advantages help create a product that is well rounded and suitable for most heavy emission industries. In order to successfully transition to renewable energy, users must fully understand the environmental and social costs that come with non-renewable energy sources and how much gasoline and fossil fuels truly cost. While transitioning to hydrogen will be a slow and long road, it will greatly serve our environment and ensure our carbon footprint is minimized.

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