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Green Hydrogen Energy Technology for Zero Carbon Emission Realization in Indonesia

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Abstract: *Indonesia is one of the world's largest emitters of greenhouse gases, hence its attempts to reduce carbon emissions are of worldwide interest. The IESR (Institute for Essential Services Reform) did a research on the best decarbonization scenario, in which hydrogen plays a larger role in Indonesia's energy system. However, we must first understand how green hydrogen technology may reach zero carbon emissions before applying it. Qualitative research methodologies are used with literature study approaches in this report.Green hydrogen generates steady, CO2-free electricity using renewable energy sources such as sun, wind, and water to electrolyze hydrogen from water, store it, and utilise it in fuel cells. Hydrogen, unlike fossil fuels, does not emit carbon dioxide. It use in an ecologically sustainable manner with reduced carbon emissions.*

Keywords: Green Hydrogen, Zero Carbon Emission, Greenhouse Gas, Decarbonization, Renewable Energy

I. INTRODUCTION

Carbon emissions are gases produced by the burning of carbon-based substances. CO2, exhaust gases from burning gasoline, diesel, wood, leaves, LPG gas, and other hydrocarbon-based fuels are examples of carbon emissions. Carbon emissions are a major source of air pollution, which is harmful to both human health and the environment. Carbon emissions can have serious consequences, such as unpredictably changing climate, which can result in flooding, starvation, and economic instability. Furthermore, if carbon emissions are permitted to continue, air temperatures will rise, resulting in global warming [1].

Indonesia is one of the world's largest emitters of greenhouse gases, hence its attempts to reduce carbon emissions are of worldwide interest. It is vital to meeting the Paris Agreement's temperature objectives, which call for net zero greenhouse gas emissions by the middle of the century. The ability of government, industry, and civil society to work together on short-term goals involving the more than 20 sectors that make up the global economy will have a substantial impact on the battle against climate change. The global economy is predicted to achieve net-zero by 2050 if all sectors participate [2].

Several governments, as well as significant corporations, have pledged to achieve carbon neutrality (zero emissions) by 2050. The lower cost of installing PLTS and PLTB, two sectors that are expected to form the backbone of decarbonization, offers up possibilities for achieving this goal. In addition to these two staple areas, certain nations have begun to notice transportation electrification and the possibility of using hydrogen. Many worldwide think tanks shared their perspectives on decarbonization initiatives aimed at achieving net-zero emissions by 2050 and green hydrogen development plans. Hydrogen has been created more recently than other renewable energy sources such as solar and wind.

In order for hydrogen to be widely used in Indonesia, major storage or battery technologies must be developed. The IESR (Institute for Essential Services Reform) did a research on the best decarbonization scenario, in which hydrogen plays a larger role in Indonesia's energy system. The need for electricity storage will rise dramatically, necessitating the development of supporting infrastructure [3]. However, we must first understand how green hydrogen technology may reach zero carbon emissions before applying it. As a result, understanding the notion of employing green hydrogen energy technology and its role in attaining Indonesia's zero carbon emissions is predicted in this study.

II. METHODOLOGY

In this paper, qualitative research methods are used with literature study methods. The data collection comes from previous scientific works and published scientific articles with indexes that have high credibility and secondary reference sources in the form of textbooks. These various sources will then be analyzed critically and comprehensively. So that will get the answer from the purpose of writing this article.

III. THE CONCEPT OF GREEN HYDROGEN ENERGY TECHNOLOGY

Hydrogen is the universe's lightest and most plentiful element, and one of the primary components of stars and interstellar plasma. Astronomical analyses of the light transmitted by the closest star and the sun revealed that hydrogen makes up around 75% of the mass of both. Hydrogen is one of the most plentiful elements on the planet. Water, hydrocarbons, carbohydrates, amino acids, and other organic and inorganic compounds all contain it. In its oxidized state, hydrogen may be found in water. Water may breakdown into hydrogen and oxygen with the help of an external energy source.Energy and water are obtained by spontaneously recombining hydrogen and oxygen, and the water is available to be utilized to restart the cycle. Electrolysis is the process of breaking water into hydrogen and oxygen using electrical energy. In a fuel cell system, the burning of hydrogen and oxygen to obtain water occurs in the opposite direction of the electrolysis reaction. While electrolysis requires energy, the combination of hydrogen and oxygen creates energy.

According to the process, liquid water may be divided into its elemental components (hydrogen and oxygen):

$$H_2 0 \rightarrow H_2 + \frac{1}{2} O_2$$

Splitting water is a non-spontaneous process that may be sped up by infusing energy, such as electrical energy, into the system. It's known as an endergonic transition, and the instrument that facilitates it is known as an electrolyzer. At least one electrolytic cell with two electrodes arranged opposite each other and separated by an electrolyte makes up an electrolyzer. Electrical effort is done to a water electrolysis cell to split water molecules into hydrogen and oxygen gases. The pH of the electrolyte affects half-cell reactions (and related processes) [4].

The majority of hydrogen now in use comes from a process known as steam methane reforming, which involves reacting methane and high-temperature steam with a catalyst to generate hydrogen, carbon monoxide, and a little amount of carbon dioxide. Carbon monoxide, steam, and a catalyst react in a later step to make additional hydrogen and carbon dioxide. The carbon dioxide and contaminants are finally eliminated, leaving only pure hydrogen. Other fossil fuels, such as propane, gasoline, and coal, can also be used to create hydrogen by steam reforming. This form of manufacturing, which is fueled by fossil fuels, produces gray hydrogen as well as 830 million metric tons of CO2 each year, which is equivalent to the combined emissions of the United Kingdom and Indonesia [5].

Currently, 96% of hydrogen is produced from fossil fuels using carbon-intensive technologies such as steam methane reforming (SMR) without carbon capture, use, or storage (grey hydrogen) or coal gasification (black hydrogen). The color of hydrogen is determined by its GHG emissions and generation method. Green hydrogen is created by electrolyzing water in an electrolyzer using energy generated from renewable sources including hydro, wind, and solar. GHG emissions throughout the manufacturing process are zero if all electrical inputs originate from renewable energy sources (and if desalinated water is required, it is powered entirely by solar and wind). Green hydrogen, in contrast to other hues, plays an important role in the energy transition and has the potential to decarbonize difficult-to-abate sectors. As an example with a large global impact, it can be used in steel production to replace coking coal in the direct reduction process; in refineries as a major consumer of hydrogen to gradually replace grey with green; and in the mobility sector for longer-haul solutions such as fuel cell buses, trains, or even ships. Industrial heat uses can also be beneficial. Long-term uses might include heating and cooling for domestic usage, as well as electricity generating (to blend with gas in CCGTs or turbines running 100 percent on hydrogen). Currently, around 55 percent of hydrogen generated worldwide is utilized for ammonia synthesis, 25% in refineries, and about 10% for methanol generation. Only roughly 10% of global hydrogen generation is accounted for by the remaining applications. It's worth noting that about two-thirds of hydrogen is created on-site for captive consumption, so there's no need for transportation and no market or pricing transparency [6].

The use of an electrolyser to create hydrogen from renewable power might make it easier to integrate large amounts of variable renewable energy (VRE) into the energy grid. An electrolyser is a device that uses electricity to split water into hydrogen and oxygen. When power generated from renewable sources is used, hydrogen becomes a renewable energy carrier that works in tandem with electricity. Electrolysers can help integrate VRE into power networks by adjusting their electricity consumption to match wind and solar power output, allowing hydrogen to serve as a form of renewable energy storage. As a result, they can supply a variable load as well as grid balancing services (upwards and downwards frequency control) while running at maximum capacity to fulfill demand for hydrogen from industry and transportation as well as gas grid injection. Hydrogen produced from renewable energy might open up a new market for renewable energy. In cases when some or all of a renewable electricity generator's production is sold to electrolyser operators under long-term contracts, it has the ability to lessen the risk of power price volatility. Depending on market conditions and laws, this may or may not be possible. In general, high electrolyser utilization rates paired with low-cost renewable power are most likely to make hydrogen from renewable electricity cost-effective. However, each conceivable manufacturing site's effects should be thoroughly evaluated. Off-grid hydrogen projects on a large scale, directly connected to solar and wind farms in high-resource regions, might offer low-cost, 100% renewable hydrogen. Due to the nature of solar and wind resources, they will have a lower electrolyser utilization rate, which will raise hydrogen costs. Meanwhile, close-to-demand, grid-connected manufacturing facilities can maximize electrolyser utilization and reduce logistics costs, but they may not have access to such cheap power rates or 100% renewable electricity supply [7].

Future energy may be produced inexpensively thanks to rapid progress, particularly in solar power (PLTS) and wind power (PLTB), which will have a direct influence on the prices of green hydrogen generation (i.e., hydrogen production through electrolysis of water). Green hydrogen is expected to account for 15-20 percent of total world energy use. If just PLTS, PLTB, and battery technologies are used, this phase will be difficult to complete. The high energy density of hydrogen energy, as opposed to PLTS, PLTB, and batteries, makes it suitable for long-distance transportation such as trucks, aircraft, and ships. Furthermore, hydrogen is more stable for long-term storage and may be used directly through existing natural gas pipelines with a maximum blending ratio of 10% [8].

IV. GREEN HYDROGEN ENERGY TECHNOLOGY REALIZING ZERO CARBON EMISSION IN INDONESIA

The vast potential of hydrogen energy, along with its ecologically beneficial nature, is expected to bring world emissions to zero in the next several decades. One kilogram of hydrogen can drive 140 kilometers and replace 10 litres of diesel or gasoline without releasing any emissions other than water as a motor fuel. Furthermore, the infrastructure for hydrogen development is already in place in virtually all nations, especially through the use of natural gas pipelines.

Green hydrogen electrolyzes hydrogen from water using renewable energy sources such as sun, wind, and water, then stores and consumes hydrogen in fuel cells to provide stable, CO2-free power and hot water. According to the International Energy Agency, while electrolysis of water presently accounts for less than 0.1 percent of worldwide specialized hydrogen production, with lower prices for renewable energy, notably solar and wind, there is growing interest in electrolytic hydrogen (green) [9].The hydrogen sector is booming all over the world right now. Hydrogen, unlike fossil fuels, does not emit carbon dioxide. Use in an ecologically sustainable manner with reduced carbon emissions [10].

Rida Mulyana, Director-General of Electricity at the Ministry of Energy and Mineral Resources (ESDM), believes hydrogen is the most important component of future energy development. Pertamina is also planning to enter the hydrogen market. Senior Vice President of Strategy and Investment at Pertamina According to Daniel Purba, his party is working on developing energy for power generation. Pertamina Power International is in charge of the first stage, which has a capacity of 0.3 megawatts (MW). Green hydrogen is the emphasis, and it will be employed in the transportation business. This industry is responsible for one-third of all greenhouse gas emissions. Christine Refina, Coordinator of the Economic Function of the Embassy of the Republic of Indonesia (KBRI) in The Hague, Netherlands, stated that the issue of green hydrogen is "very relevant and strategic" because it is linked to sustainable energy supply and the Indonesian government's commitment to reduce carbon emissions [11]. A ship that runs on green hydrogen fuel is another example of how green hydrogen may be used. Green hydrogen fuel is around 4-8 times cheaper than sulfur fuel oil, according to risk management firm DNV GL's estimations. As the cost of renewable energy and electrolyzers falls, green hydrogen is predicted to become more affordable over the next several decades [12].

If hydrogen is available at a reasonable price, the transition to low-carbon hydrogen production should follow a process in which fossil fuels play an important role in meeting market demand by developing technologies that use renewable energy (such as fuel cells, mobile applications, hybrid fuel cells / internal combustion engines).The conversion of natural gas or coal into hydrogen, in particular, is a viable option for reducing CO2 emissions from combustion operations in the transportation sector or for power generation. In this instance, CO2-free technology for exploitation of fossil fuels is required to make their usage consistent with emission reductions [13].

V. Conclusion and Recommendation

Pertamina Geothermal Energy (PGE) is beginning to investigate into the production of green hydrogen in Indonesia. The company's seriousness in generating green hydrogen, according to PGE President Director Ahmad Yurniarto, will begin this year. The company's current geothermal operating area will be used for hydrogen research (WKP). Currently, the firm is cooperating with a number of linked ministries to use green hydrogen. In addition, to conduct this business, the company is searching for strategic partners. This is due to the fact that, in comparison to other forms of hydrogen, the cost of producing green hydrogen is still rather high. However, he believes that as technology advances, the cost of producing green hydrogen will drop. Furthermore, the global market for green hydrogen is rather significant. Given that all governments have begun to concentrate their efforts on reducing greenhouse gas emissions [14].

However, it is preferable not to employ geothermal renewable energy sources to further minimize the cost of creating green hydrogen. Because geothermal energy is more expensive than other renewable energy sources, if you utilize renewable energy sources other than geothermal, green hydrogen energy can be used more quickly, and zero carbon emissions can be attained sooner.

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