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Hydrogen Energy and the Prospect of Applying Hydrogen Energy Technologies in Vietnam

TRAN The Vinh, NGO Phuong Le
[1]*Institute of Energy Science, Vietnam Academy of Science and Technology*
A9 Building, 18, Hoang Quoc Viet str., Cau Giay dist., Hanoi, Vietnam
Corresponding Author: Tran The Vinh

ABSTRACT : *Hydrogen is used in industry as raw material for chemical industry and in energy sector as fuel source for combustion engines, daily needs, fuel cell with many environmental and economic advantages. The hydrogen production from renewable energy (solar, wind) shows high potential as the hydrogen can be stored for transportation or some industrial processes or converted back to electricity to feed the grid at peak hours. With the blooming of renewable energy in Vietnam, hydrogen production from renewable energy now have chances to develop. This paper take a look at the current hydrogen production and propect of applying hydrogen energy technologies in Vietnam.*
KEYWORDS *hydrogen, hydrogen production, water electrolysis, renewable energy, offshore wind power.*

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I. INTRODUCTION

Hydrogen is mainly used in industry and energy:

- In industry, H2 is used as a raw material for the chemical industry to make ammonia, methanol, oil refining, fertilizer production, metallurgy industry, cosmetics, semiconductors...

- In energy, H2 is a potential fuel source with many favorable environmental and economic advantages. When used as a fuel, H2 can be burned directly in internal combustion engines, similar to today's popular gasoline-powered vehicles. H2 can also replace natural gas to provide energy for daily civil needs such as cooking, heating, lighting... In particular, H2 has been used as a fuel for rockets in the industry space and defense industry. H2 can also be used as an energy source for fuel cell systems, thanks to the electrochemical process to generate electricity.

Hydrogen production from wind or solar power plants shows a high potential for applications due to the ability to electrolyze water into hydrogen and oxygen without the emission of greenhouse gases by not consuming fossil fuels. The generated hydrogen is stored for later use at hydrogen fuel stations, (for transportation or some industrial processes), or converted back into electricity to feed the grid at peak hours [1].

The most promising hydrogen production technologies from water are PEM (Polymer electrolyte membrane) and alkaline water electrolysis. In terms of application to energy storage, PEM electrolysis has the advantage of operating with high current density [2]. This can help reduce operating costs, especially for the location where the grid is connected to highly variable energy sources such as wind and solar.

Vietnam’s leadership is further committed to continue the process of energy transition into renewable energy. Therefore hydrogen production from renewable energy will have more chances to develop.

This paper takes a look at the current status of hydrogen as an energy source, hydrogen production and its possibility to apply the hydrogen energy production in Vietnam.

II. HYDROGEN AS ENERGY SOURCE AND HYDROGEN PRODUCTION

A. HYDROGEN AS AN ENERGY SOURCE

Hydrogen (hydrogen) is a chemical element in Mendeleev's periodic table with an atomic mass of 1. In the free state and under normal conditions, H2 is colorless, odorless, tasteless and has a density of 1. /14 density of air. On Earth, H2 combines with oxygen in water, with carbon and other elements in organic compounds of plants and animals.

H2 is very chemically reactive with other chemical elements, especially oxygen, and produces a large amount of energy in the form of heat or electricity through the following chemical reaction:

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

H2 has a large calorific value (120 MJ/kg), more than 2 times larger than methane CH4 (56 MJ/kg) and 5.7 times larger than coal (21 MJ/kg). The important feature of H2 is that the molecule does not contain any other chemical elements, such as carbon (C), sulfur (S), nitrogen (N), so their combustion products are only water (H2O), therefore it is the ideal clean fuel in the field of transportation.

Hydrogen is not a primary source of energy (not available for direct extraction) but rather a source of energy produced and processed from water or other hydrocarbon compounds. Figure 1 presents a diagram of the basic principles of the production, processing and use of hydrogen energy.

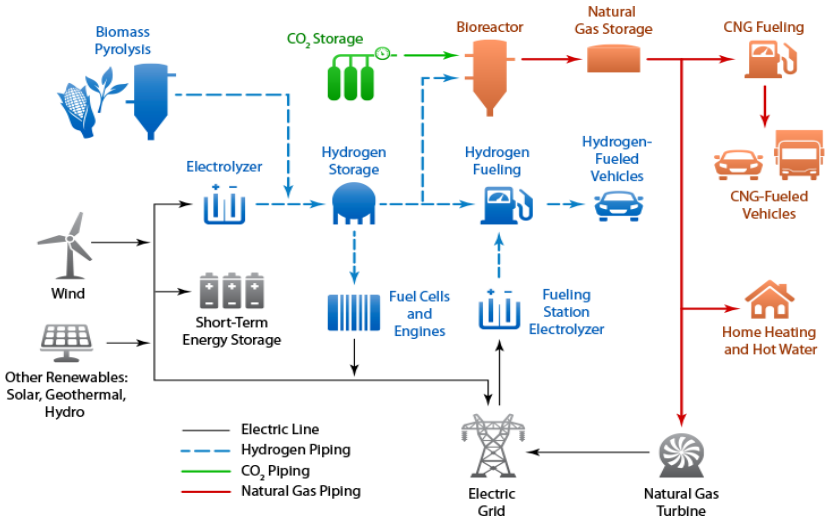

Figure 1. Schematic diagram of the production, processing and use of hydrogen energy

Source: https://www.nrel.gov

As an energy source, hydrogen has the following advantages:

- H2 energy is considered a form of chemical energy with many advantages because the product of this process is only pure water and energy without any harmful waste to the environment, no CO2 emissions 2 causes global climate change, is an almost inexhaustible or renewable source of energy.

- H2 energy contributes to ensuring energy security, can be produced from many different available sources, especially from renewable energy sources such as wind and solar, without depending on other sources. sources imported from abroad. With the role of "storage" of energy, H2 makes the distribution and use of energy convenient and can be stored for a long time, especially H2 produced from renewable energy is considered a transport material. move renewable energy to areas with no advantage or store it for use during periods of the night, with no wind...

- H2 energy can solve many different problems such as zero carbon emissions in some industries that are difficult to reduce such as transportation, chemicals, metallurgy, helping to improve air quality and public health. copper.

- H2 energy can be produced, stored, transported in the existing natural gas (LNG) transportation infrastructure, can be used in the form of conversion into electricity or gas such as CH4 for needs such as living, industrial, livestock or as fuel for means of transport.

- In terms of safety, the low density and fast diffusion allow H2 to escape quickly into the atmosphere, if a leak occurs. Especially with its non-toxic and non-corrosive nature, if H2 is released, it will evaporate almost completely and leave no harm.

- Equipment using H2 fuel is a fuel cell with quiet running characteristics, no noise and vibration like an internal combustion engine. Fuel cells are much more efficient than internal combustion engines and are more energy efficient. According to the assessment, fuel cells will be a promising energy source, playing a key role in the hydrogen economy in the future.

B. HYDROGEN PRODUCTION FOR ENERGY PURPOSES

Hydrogen production is a group of the method for create hydrogen. As of 2020, hydrogen is largely (~95%) produced from fossil fuels by steam reforming of natural gas, partial oxidation of methane, and gasification of coal [3]. However, this method is not applied to create an energy source, but only to provide raw materials for chemical industries, fertilizer production, petroleum refining, etc.

Other aquaculture methods include biomass gasification, CO2-free methane thermoelectricity, and water electrolysis. The latter processes, methane heating as well as water electrolysis can be done directly with any power source, such as solar power.

The most potential green method of hydrogen production for energy source is Water Electrolysis. Currently, there are 4 popular electrolysis technologies:

- Electrolysis with the electrolyte is water or alkaline solution. The two parts of the negative electrode and the positive electrode are separated by an ion diaphragm to avoid mixing the two gases produced.

- Water electrolysis at a high temperature of about 800-1000 ^{o}C makes the electrolysis process take place with higher efficiency, reducing power consumption. The heat supplied is mainly used from solar-concentrated parabolic pans or utilizing excess heat from other suitable industrial energy processes.

- High-pressure water electrolysis can produce hydrogen at pressures up to 5 MPa. The process is still in the research and improvement stage.

Water electrolysis provided by electricity from renewable energy sources such as solar power, wind power, integrated hydroelectricity is considered clean and sustainable and is the development trend of the future.

III. THE POSSIBILITY OF APPLYING HYDROGEN ENERGY TECHNOLOGIES IN VIETNAM

Currently, hydrogen produced in Vietnam is mainly by thermochemical fuel technology to serve the needs of industrial hydrogen in fertilizer production, petrochemical refining, etc., the energy hydrogen industry has received little attention. However, this is about to change.

In the spirit of Resolution 55-NQ/TW of the Politburo dated February 11, 2020 on researching, building and encouraging the use of hydrogen energy in line with the general trend of the world, recently, in Decision No. 1658/QD-TTg dated October 1, 2021, the Prime Minister approved the National Strategy on Green Growth for the period 2021 - 2030, with a vision to 2050, which clearly states the tasks of the Ministry of Industry and Trade on research develop a mechanism to encourage the development of hydrogen fuel associated with offshore wind power.

This also marks an internationally unprecedented market growth of renewable energy, where solar PV capacity (plus wind turbine capacity with approximately 750 MW) accounts for approximately 25% of the currently installed total power capacity of the country – developed within less than two years. Only RTS, by the end of 2020, more than 105,000 households and businesses have installed rooftop solar electricity in Vietnam with a capacity of about 9600 MWp (equivalent to 7700 MWac), accounting for 11% of the installed capacity of the whole electrical system and 4.5% of Vietnam's electricity sales.

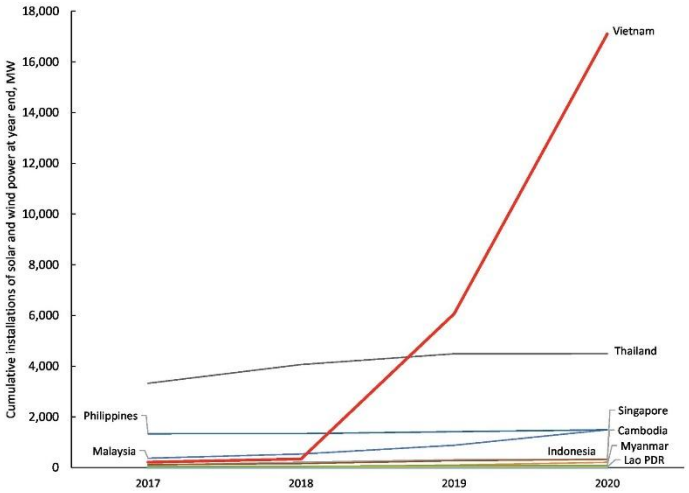

Figure 2. ASEAN total solar plus wind power capacity, 2017–2020.

Source: International Renewable Energy Agency (2021).

It is also expected that at the end of 2021, wind power capacity also raise drastically. Vietnam has wind and solar power potential, especially offshore wind power up to 599GW. Vietnam is striving to produce about 3,000 - 5,000 MW of offshore wind power by 2030 and 21,000 MW by 2045 [4]. According to a World Bank report, there are two factors that greatly affect the cost of green hydrogen production: the cost of input electricity, which accounts for 80%, and the cost of storage and transportation. With the free green energy from wind and solar, hydrogen production from water electrolysis might increase in the future.

Currently, Vietnam has a number of investors interested in developing hydrogen, including Enterprize Energy Group (EE-UK) has proposed to the Government and the MoIT to combine the development of Thang Long offshore wind power project (in Binh Thuan province) with green hydrogen production with a scale of 2,000MW, total investment of about 5 billion USD, expected implementation time from 2022 to 2030 [3].

IV. CONCLUSION

Hydrogen H2 is considered a form of chemical energy with many advantages because the product of the energy-generating metabolism is just pure water without harmful waste to the environment, no gas emissions. CO2, causing global climate change. Hydrogen is an almost inexhaustible and renewable source of energy. In particular, H2 can be produced from many other available sources such as wind, solar, biomass, so it will make an important contribution to ensuring energy security.

As a clean energy carrier, hydrogen allows to reduce carbon emissions in the most difficult industries to reduce such as transportation, chemicals, metallurgy. H2 energy can be produced, stored, transported in the existing natural gas (LNG) transportation infrastructure, can be used in the form of conversion into electricity or gas such as JUST4 for other needs. demand such as daily life, industry; According to the International Energy Agency (IEA), H2 will be a clean and safe energy source, used by many countries in the coming time.

Research and development of hydrogen energy sources have been interested in many countries. The hydrogen development program began in the United States in 1970 and has been given new impetus since the beginning of the twenty-first century. Especially from 2010 onwards, many countries in the European Union, Japan, China, Australia... have developed and implemented their hydrogen development strategic programs. The strategic issues raised are: (1) Clean hydrogen production with CO2 recovery and storage; research to improve the efficiency and durability of water electrolysis technology; (2) Hydrogen capture and transport; (3) Development of the use of hydrogen derived from renewable energy as a means of energy storage;

In the long-term view, the IEA has made 6 recommendations including:

- Determining long-term targets for H2 energy in the national energy development strategy, including both production and use targets in energy-using fields and industries;
- Encourage research, development, production and commercialization of H2 fuels derived from renewable, clean and low-carbon energy;
- Having policies and mechanisms for sharing and minimizing risks for investment, production and development projects related to H2 energy for investors;
- Support research and development (R&D) to reduce the cost of H2 energy from production technology, storage, transportation, distribution and equipment, application products;
- Create a strong enough legal framework for management, and attractive enough support and promotion mechanisms to attract the attention of investors;
- International cooperation, enhancing the exchange of information on techniques, technologies and standards in order to connect and strengthen the support of investors to develop the associated market.

Currently, hydrogen is mainly produced by thermochemical technology of hydrocarbon fuels (gas, coal, oil, biomass). This is a technology that has been completed and produces 95% of the hydrogen consumed in the world today (65-70 million T/year). It is important to note that this technology generates a large amount of CO2 (10 kg CO2/kg H2). To reduce emissions, developed economies have used a combination of thermochemical fuel technology with CO2 gas collection and storage technology to create blue hydrogen products;

The technology to produce hydrogen green (hydrogen green) that is considered sustainable and renewable, with no or little greenhouse gas emissions is a water electrolysis technology using renewable energy sources (wind, solar, etc.). , biomass, hydroelectricity). This technology aims to use energy from surplus renewable energy sources as a direction of energy storage. Many hydrogen storage technologies have also been researched and perfected, promising to create a potential technology chain in the world hydrogen energy industry.

Currently, hydrogen produced in Vietnam is mainly by thermochemical fuel technology to serve the needs of industrial hydrogen in fertilizer production, petrochemical refining, etc., the energy hydrogen industry has received little attention. Based on the above discussions, based on the current situation of research activities of world research organizations as well as the need to develop scientific and technological research activities in the field of hydrogen energy, in the opinion of The individual of the staff implementing the project proposes to develop and implement a research and development direction for the production, storage and use of green hydrogen energy. It focuses on some of the following orientations:

(1) Research, apply and develop technology to produce hydrogen energy from renewable energy sources such as wind and solar;

(2) Research and application of hydrogen gas storage technology using nanomaterials.

(3) Research on fuel cell technology for the development of zero-emission transportation.

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