

Analysis on Power to Hydrogen and its Benefit

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Abstract. The purpose of this paper is to give a general idea of how power to hydrogen used in the future. Also give the analysis on advantages and disadvantages of power to gas. To support the analysis, the paper provides the method of how to make the hydrogen and the application of hydrogen. The technology is to separate the gas into hydrogen and methane to be widely used, they are convenient for transportation, small marginal coefficient of gas storage cost, and convenient for long-term and large-scale storage. Compared with other forms of storage of electric energy, such as pumping energy storage and battery energy storage, there is a broader prospect for storing electrical energy in the form of gas.

Keywords: power to hydrogen, benefit, hydrogen production.

1. Introduction

With the development of the world, so does the demand for energy, and the day when the world's resources and energy resources will run out, so the world needs more renewable energy. In addition, today have a new technology called power to gas, and it can produce hydrogen. Hydrogen is an ideal secondary gas; it can help people to use less electricity and it not harmful to the environment. Hydrogen is also a clean energy source that is technically feasible, relatively cheap and widely used. As the demand for renewable energy continues growing, technology for storage for this energy is critical. Because many things, hydrogen is an ideal medium for storing all kinds of these energy. Electric hydrogen conversion refers to the use of water electrolysis to consume electric energy to reduce the peak load of the power grid and achieve the purpose of converting excess electricity to hydrogen. Power to hydrogen conversion will become an important link between seasonal power surplus and hydrogen production. With the reduction of investment costs, the improvement of operating efficiency, the gradual opening and improvement of the competitive energy market, and appropriate policy support (such as the introduction of carbon emission indicators), it is believed that the economy of this technology will be greatly improved. However, at present, there are still many shortcomings in the relevant regulations of electricity-to-gas technology, system operation and market supervision framework. Therefore, in the actual operation of the project, uncertainties such as taxes, electricity bills and interest rates will bring certain challenges. Since the EU has strengthened its laws on greenhouse gas emissions (CO, HC, and NOX), several methods of producing hydrogen are taken into consideration. It is concluded that only "Green hydrogen," or hydrogen produced from renewable energy sources, may have a substantial impact on CO₂ emissions. Furthermore, hydrogen availability throughout the major shipping routes is ensured because hydrogen is closely related to the chemical sector, which in turn strongly depends on waterways [1].

2. How to make Hydrogen

2.1. Power to hydrogen

With the fast development of society, power to hydrogen is a very innovative and hopeful technology in nowadays. In modern society, the demand for the renewable sources increases. This technique can effectively solve this problem. Hydrogen can directly replace fossil fuels in transportation and industry when it is created through hydro-electrolysis. This helps to transfer renewable energy to other energy sectors. A collection of devices known as "power to gas" can convert excess electricity into energy that can be transported and used in other locations. Electricity

is utilized in the power to hydrogen process to electrolyze water to produce hydrogen, which is then stored. Hydrogen is produced through electrolysis, a process in which water is broken down into hydrogen and oxygen, in the power to hydrogen process. In the power to methane process, methane is created through electrolysis, and methanation requires carbon dioxide and hydrogen, both of which are produced during electrolysis [2].

Hydrogen produced has high purity and no pollution, and has been used in many industrial fields, such as fuel cells for cars and industrial problems. Besides, hydrogen is a very environmentally friendly, efficient and secure gas. In addition, the cost of the power to gas technology is very high, take 1000 Nm³/h scale PEM electrolytic cell to produce hydrogen as an example.

It works 2,000 hours a year and produces 2 million cubic meters of hydrogen per year; 1000 Nm³/h PEM electrolyzer cost 30-million-yuan, land cost, civil construction and equipment installation cost 2-million-yuan, labor cost and maintenance cost 400,000. Each cubic meter of hydrogen consumes 0.001 tons of raw water, 0.001 tons of cooling water, and the water fee is 5 yuan/ton. The power consumption per cubic meter of hydrogen is 4.5 kWh, and a kilogram of hydrogen is about 11.2 standard cubic meters, that is, 50.4 kWh of electricity is needed to produce a kilogram of hydrogen in electrolytic water. According to the industrial electricity price of 0.4 yuan/kWh (degree), the electricity fee is 20.16 yuan, and pure electric vehicles with the same electricity can achieve a range of nearly 400 kilometers Project cost (yuan/Nm³). Depreciation cost 1.55 Raw material cost 0.01 Labor operation and maintenance cost 0.2 Power consumption cost 1.8 Unit volume hydrogen cost 3.56 Conversion device, that is, the cost of power to hydrogen production is 39.87 yuan/kg, of which the electricity cost accounts for 50% The procurement cost of PEM electrolytic tank is too high, the depreciation cost is high, and the depreciation cost of equipment accounts for 44% of the total cost. Therefore, hydrogen production stations may develop towards the integration of power generation and hydrogen production, such as using photovoltaic power generation to reduce electricity costs. A long-term sustainable and secure energy supply in the European Union (EU) is viewed as requiring a hydrogen-inclusive economy. The benefits of a hydrogen-inclusive economy must be maximized [3].

2.2. Electrolysis

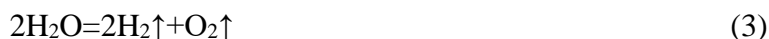
Electrolysis of water refers to the process of producing hydrogen and oxygen by direct current electrolysis of water. When an electric current passes through water, hydrogen is formed by electrolysis and formed in cathode, oxygen is formed at the anode. Functions that during reactions on the cathode side are as follow



On the anode side, the function is as follow



The total function of the reaction is as follow



Amount of hydrogen produced is about twice that of oxygen. Hydrogen and electrolyte from the cathode side of each electrolytic chamber in the electrolyzer, with the help of the head and gas lift of the circulating pump, the gas-liquid separator separates hydrogen and the electrolyte under the action of gravity, the electrolyte circulates back to the electrolyzer, and hydrogen enters the cold. After separation, washing, deoxidation and drying, H₂ with high purity is obtained. After compression, it is temporarily stored in a buffer tank, and the gas process is filled through a hydrogenation column and shipped out.

Hydrogen and oxygen are generated, and these two gases have already existed in the atmosphere, so they are not harmful gases and there is no pollution to the environment. Hydrogen heat is renewable

and pollution-free because hydrogen is burned to generate water, which has no pollution to the environment, and water can generate hydrogen and oxygen by electrolysis and be recycled. Electrolysis water hydrogen production is a simple and environmentally friendly hydrogen production method. By electrolyzing water, it is possible to decompose water into hydrogen and oxygen, thereby achieving the conversion and storage of clean energy. Electrolysis hydrogen production has advantages such as environmental friendliness, clean utilization of renewable energy, and flexibility, and is expected to be developed in the future. The energy field has been widely applied. With the continuous development of science and technology, hydrogen production through electrolysis of water. Technology will also continue to improve and make greater contributions to the development of the clean energy industry. The heat released by hydrogen combustion is large, and the product does not pollute the environment, so hydrogen energy is a very ideal new energy. At room temperature, the chemical properties of hydrogen are very stable, and it is not easy to react with other substances (Fig. 1).

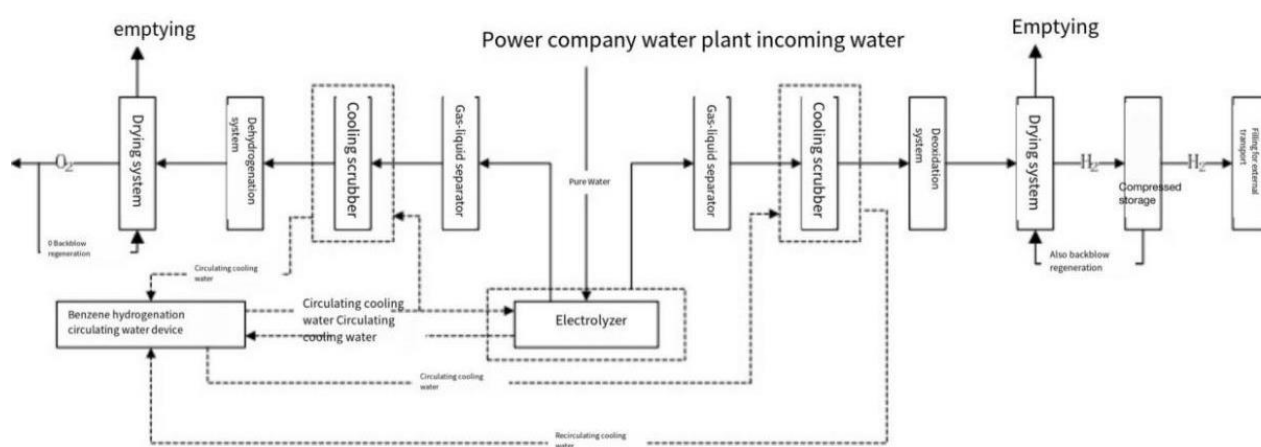


Figure 1. Process flow chart of hydrogen production [4]

3. Hydrogen application

3.1. Hydrogen application

Hydrogen has many aspects for people and environment using. First of all, hydrogen is a gas that can be used in many aspects in the metallurgical industry. Hydrogen is a good high-energy fuel. High-energy fuel refers to the fuel that uses hydrogen as a source of energy. Hydrogen has the advantages of high calorific value, wide source and no pollution, so it is widely used in the field of high-energy fuels. It can be used to smelt metals. Hydrogen has good reduction properties and can participate in the reduction reaction of metal oxides, so it can promote the deoxidation of metals and reduce their melting point. In the smelting of metals such as aluminum, steel and copper, adding an appropriate amount of hydrogen can significantly reduce the melting point of metals and improve production efficiency. Hydrogen can react with oxides and other harmful gases on the metal surface to form water and other gases, thus removing impurities on the surface of the metal material. Besides, hydrogen can also be used to make semiconductor materials and high-purity silicon. In the chemical industry, hydrogen can be used to make ammonia and fertilizers. It provides important energy support for industrial production, as shown in fig.2. Apart from that, in the aerospace field, hydrogen is also a very light, high energy density fuel. Hydrogen is an ideal secondary energy source, which can reduce dependence on traditional energy sources, reduce the emission of carbon dioxide and environmental pollution and energy loss. In addition, hydrogen also acts as a natural reducing agent in food processing. The reductive properties of hydrogen can be used to smelt non-ferrous metals and high-purity silicon, synthetic ammonia, hydrochloric acid, petroleum ammonia, hardening oil, high-efficiency fuel, liquid ammonia may become a rocket propellant. Hydrogenizes can convert unsaturated fats into saturated oils and fats. In the food industry, hydrogenators are used to make

hydrogenated vegetable oils, such as margarine and butter. Hydrogenators convert fat into saturated oil and fat through hydrogenation. This process is an intermittent process, which ensures that the temperature is between 70-80°C by keeping temperature stable, also the appropriate mixing mixture. Finally, the hydrogenated oil is pumped out to form a slurry and remove the catalyst solid in the filter. After cooling to room temperature, the hydration oil will solidify. Hydrogen has a wide range of applications as an energy carrier. In addition to heating and CHP, hydrogen can also be used as fuel for hydrogen fuel cells for transportation vehicles such as cars, trains, ships and bicycles. This is because hydrogen, as a clean energy source, can effectively store and transport energy. By using hydrogen as an energy carrier, energy can be effectively converted from one form to another to storage and utilization of energy in the transportation process. Therefore, hydrogen has important application value in the field of energy carriers. Solutions for power to gas can assist in balancing local power networks by absorbing excess renewable electricity and converting it to hydrogen [5]. Given that wind and solar energy are not always accessible, the switch to a green energy system presents significant difficulties. Producing synthetic natural gas and hydrogen from excess wind and solar energy is one way to overcome this problem so that the green gas may be utilized to produce electricity when wind and solar energy are not available [6]. The hydrogen business could experience a similar fate to the local oil and gas industry if it has the necessary intellectual and technological competence [7].

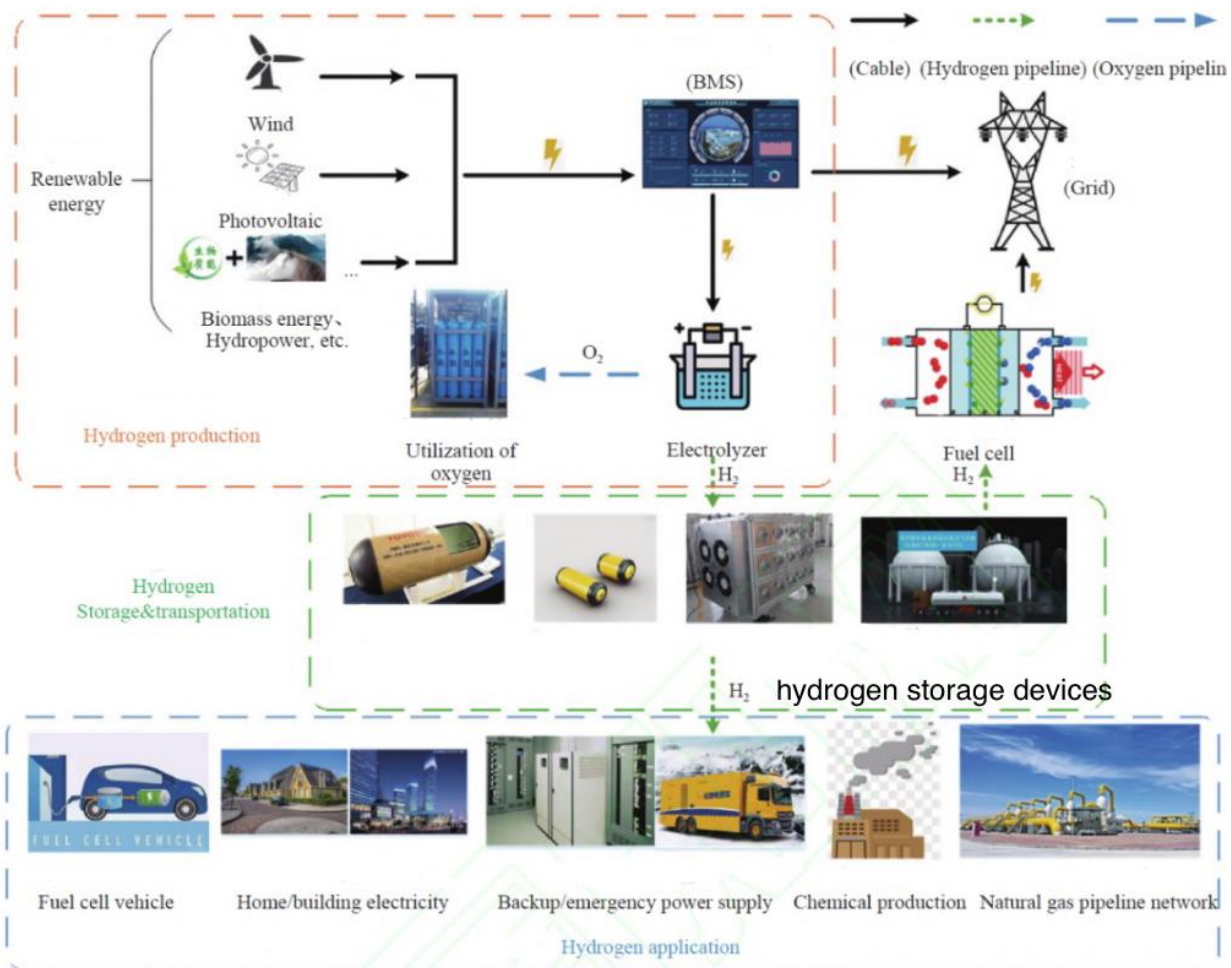


Figure 2. Schematic diagram of the whole industrial chain of the using of hydrogen [8]

3.2. Power to hydrogen's benefits

Power-to-gas technology is the technology of converting electricity into gas fuel. The method is to decompose water into oxygen and hydrogen by electrolysis. Power to gas electrolyte water to

obtain hydrogen, and further synthesize methane and other gases such as hydrogen and carbon dioxide, so as to convert electrical energy into a relatively convenient gas for storage.

Hydrogen can be used as a means of storing energy, so this use is also used as hydrogen energy storage. Hydrogen can be transmitted to hydrogenation stations for use in hydrogen fuel cell vehicles. Hydrogen can also further synthesize methane and introduce natural gas pipelines. It can also be used directly or converted into synthetic gas such as methane or liquefied petroleum gas, etc. through other steps, this ingenious conversion method has a good application prospect in cross-season energy storage. The gas generated by the electric-gas technology can not only be used as fuel to generate heat through combustion, but also can be used as a power source for generators. In addition, the hydrogen energy generated can be used as a fuel cell, which further promotes industry coupling and also promotes the integration process of integrated energy technologies. It can not only reduce carbon dioxide emissions, but also achieve almost lossless storage over a long period of time. When electricity is in short supply, stored hydrogen is used to generate electricity in fuel cells, using electricity and waste heat.

Power to hydrogen is such a renewable technology that it would not produce any harmful chemical, in contrast, traditional fossil fuel combustion generates a large amount of carbon dioxide and other harmful gases, causing great pollution to the environment.

The DOE supports research and development of a wide range of technologies in order to manufacture affordable hydrogen in the future in ecologically friendly methods. Mid-term cost targets for renewable resources like wind and biomass are predicted to be met, whereas longer-term viability goals for net-zero emissions technological pathways like solar energy are anticipated [9].

The energy utilization rate of electrolytic water to produce hydrogen is very high, which can reach more than 90%. This is because electric energy can be fully utilized, and hydrogen production can be increased, which is very beneficial to save energy and improve efficiency. Power-to-gas technology succeeded in the transmission of energy from the power system to the natural gas system, providing new method for the absorption of renewable energy. Power to gas technology is a new method to solve the problem that peak cutting and valley filling in thermal power plants, and has the potential of flexible operation. This technology enhances the connection between power system and natural gas system, helps to realize coordinated and optimized operation of multi-energy system, and improves social and economic benefits. In China's market environment, the power to gas technology makes the multi-energy market more closely connected. This technology can produce sufficient green energy, reduce carbon dioxide emissions, and contribute to the development of the natural environment [10].

4. Conclusion

Power to hydrogen is very beneficial for the increasing of global demand for renewable energy in the future, and this energy conversion technology can provide a stable energy supply at any time, solving the problem of energy storage and application. This also is a low-carbon, environmental-friendly, clean technology. The equipment and process of electrolyzing water to produce hydrogen are very safe and will not cause dangerous and damaging accidents. At the same time, there are no harmful chemicals produced in the hydrogen production process, which is very beneficial to human health and environmental protection. Power to gas will be widely used. Besides, it also will make environment better, decline the greenhouse gases producing. Power to hydrogen can use any renewable energy, including solar energy, wind energy, hydropower, etc. This also means that this hydrogen production method has a wide range of applications and can meet a variety of different energy needs. Power to gas can be used in many places, like used as a fuel cell for vehicles, industrial oil refining and chemical engineering aspects.

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