

Feasibility Analysis of Coordinated Development of Hydrogen Energy and Solar Energy

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Abstract. Nowadays, the world's demand for new energy continues to increase, however, single new energy often has low efficiency and high cost. Therefore, how to realize the mutual promotion and common development of the two new energies is an issue worthy of study. This paper briefly introduces hydrogen energy and solar energy, including the applications and development prospects of these two energy sources. Hydrogen fuel cell and hydrogen power vehicle are two examples of hydrogen energy application. In the long run, hydrogen energy has a wide development prospect, it can be applied in transportation, metallurgy, etc. However, people still have to solve some problems, such as hydrogen energy has potential safety hazards, and is difficult to be transported and stored. Solar energy is mainly used in solar photovoltaic power generation, solar water heaters, etc. This energy has a wide development prospect, but the efficiency of solar energy products is low. Besides, this paper compares and analyzes the advantages and disadvantages of these two new energy sources, and discusses the possibility that solar energy and hydrogen energy can develop collaboratively according to their advantages and disadvantages. Tentatively put forward suggestions on how to realize the complementary development of advantages and disadvantages of solar energy and hydrogen energy. In the future, improving the efficiency of solar hydrogen production technology and reducing its cost are the main efforts to achieve the coordinated development of hydrogen energy and solar energy. At this stage, researchers pay more attention to solving the problems that arise in the application of a single energy source. This paper provides new ideas on how to solve these problems.

Keywords: Hydrogen energy; solar energy; hydrogen production; application.

1. Introduction

The energy issue has always been the most critical factor in the process of human development. Nowadays, the main energy sources in the world, including oil, coal, and natural gas, are non-renewable energy. The role of new energy, such as wind, geothermal energy, nuclear energy, and biomass energy, is limited or the technology is still not developed. However, the world's demand for new energy continues to increase. As a result, it is urgent to develop new energy instead of fossil energy. In September 2020, at the 75th United Nations General Assembly, China proposed the "double carbon target", which means people have to reach the peak of carbon emissions by 2030 and achieve carbon neutrality by 2060.

The proposal of a "double carbon target" shows China's magnanimity and ambition, but China is still a developing country, it is undoubtedly a huge challenge for people to achieve it. To meet the requirements of "double carbon" target, people have to develop more clean energy. Hydrogen energy and solar energy are the two most mature and are well known new energy sources. Hydrogen has a high combustion calorific value and good thermal conductivity, and the combustion product of hydrogen is water, which will not cause pollution. Solar energy is widespread, it does not pollute the environment, and the total amount of solar energy is large. However, hydrogen energy is difficult to be stored and transported, and solar energy is unstable. If we can directly convert solar energy into hydrogen energy in areas where hydrogen energy is needed and store it, we can solve the above problems. Therefore, how to realize the co-development of hydrogen energy and solar energy is a problem worthy of study.

This study introduces the application scenarios of hydrogen energy and solar energy, and compares their advantages and disadvantages. According to the respective characteristics of these two kinds of energy, this paper tentatively puts forward suggestions for the co-development of the two kinds of energy.

2. Hydrogen Energy

2.1. Hydrogen

Hydrogen mainly occurs in the combined state of the earth and is widely distributed. Hydrogen belongs to clean energy, because of its lightweight, good thermal conductivity, universal existence, high calorific value, no pollution, and other characteristics, it is widely believed that hydrogen energy is the most potential clean energy in the 21st century. At this stage, the commonly used methods for hydrogen production mainly include electrolytic water hydrogen production, fossil fuel reforming hydrogen production, industrial by-product hydrogen production, renewable energy hydrogen production, direct pyrolysis, biomass hydrogen production [1].

2.2. Application Scenario of Hydrogen Energy

2.2.1. Hydrogen fuel cell

Fig. 1 demonstrates the working of a hydrogen fuel cell. Hydrogen reacts at the anode, while oxygen reacts at the cathode. At the same time, hydrogen diffuses outward and reacts with the dielectric. The generated electrons reach the cathode through the load. Hydrogen fuel cell vehicles are considered to be one of the ideal solutions for sustainable development in the future transportation field. According to the quality and operation range of vehicles, hydrogen energy is widely used in the transportation field, including passenger cars, passenger cars, forklifts, light trucks, heavy trucks, urban rail vehicles, ships, etc.

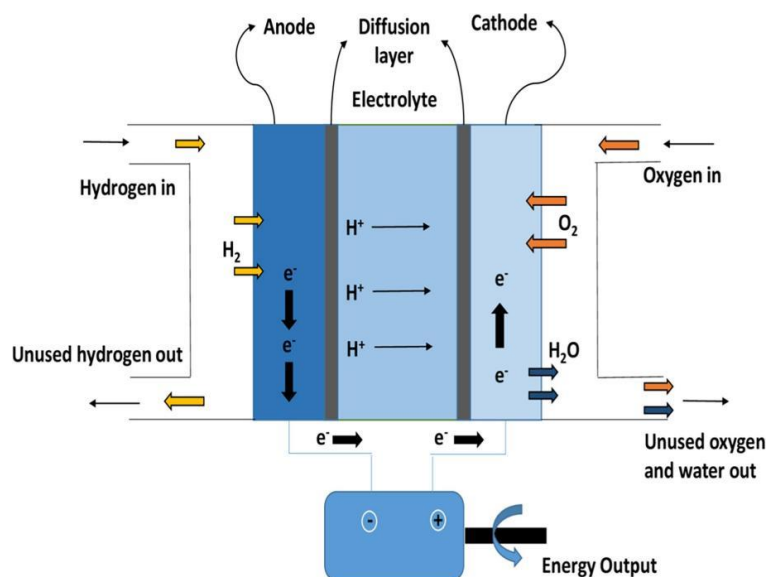


Fig 1. Block diagram of a hydrogen-based fuel cell [2].

2.2.2. Hydrogen-powered vehicle

Vehicles that can use hydrogen energy mainly include hydrogen internal combustion vehicles and hydrogen fuel cell vehicles. A hydrogen internal combustion engine vehicle uses hydrogen as fuel and drives the vehicle through the power generated by the co-combustion of hydrogen and oxygen in the air. The hydrogen fuel cell vehicle uses the electric energy stored in the battery on the vehicle to create the power to drive the vehicle. The hydrogen energy uses electric energy to create power to drive the vehicle, which is generated by the hydrogen fuel cells carried on vehicles. The wide application of hydrogen-powered vehicles can reduce greenhouse gases. It is the cleanest vehicle in

the world, and the endurance of hydrogen-powered vehicles is stronger. However, at present, the facilities to provide hydrogen for hydrogen-powered vehicles are not perfect, and the purchase cost is high [3].

2.3. Development Prospect of Hydrogen Energy

Hydrogen energy is a kind of energy with great development potential, it be used for power generation and heating; it can replace traditional fuels, and improve energy structure; it can also help reduce greenhouse gas emissions and improve air quality. However, from the current point of view, if hydrogen energy is to be commercialized in the future, the following conditions need to be met: (i) policy support is needed to promote the development of hydrogen energy; (ii) the related cost of the hydrogen energy industry is low and has certain competitiveness; (iii) the technology is safe and reliable, without potential safety hazards, and has high social acceptance [4].

3. Solar Energy

3.1. Solar Energy

Solar energy is the energy generated by solar thermal radiation, and the sunlight that can be seen everywhere in daily life is its macro performance. Solar energy is renewable and clean energy. As a new energy, solar energy has been widely used in electric power generation. According to the different principles, solar electric power generation includes optical-thermal-electric conversion mode and optical-electric direct conversion mode. At present, the principle of the most widely used solar photovoltaic electric power generation technology is optical-electric direct conversion [5].

The solar photovoltaic power generation system mainly includes solar photovoltaic cells, power storage cells, inverters, control storage devices and other components. The solar photovoltaic cells transform the received solar energy into electrical energy, but the electrical energy at this time cannot be directly used, it can only be used after being processed by the inverter. The power generation system mainly includes independent photovoltaic power generation systems and grid-connected photovoltaic power generation systems [5].

3.2. Application Scenario of Solar Energy

At present, solar energy is mainly used in solar photovoltaic power generation technology. Nowadays, with the improvement of solar cell technology efficiency and the reduction of its cost, solar photovoltaic power generation technology has also made breakthrough progress. Scale of solar photovoltaic power generation technology is increasing, and grid-connected photovoltaic power generation system is the most widely used power generation system. Photovoltaic grid-connected power generation technology can be used to set photovoltaic cells at the fence, roof, and other positions of buildings, which can meet the power demand of residents [5]. Besides, solar water heaters are also widely used in life. Solar water heaters can convert the received solar energy into heat energy to heat the water in the water heater, it can produce hot water for users [6]. With the maturity of the manufacturing technology of water heaters, its utilization efficiency of heat energy is also improving, and many high-performance solar water heaters have emerged.

3.3. Development Prospect of Solar Energy

Through analysis, the development trend of solar energy is obtained: (i) the efficiency of solar thermal utilization continues to improve; (ii) improve the quality of solar collectors [7]; (iii) breakthrough in solar cell development technology. Collectors are the main component of solar energy applications. However, the main drawback of current collectors is the lack of thermal energy storage effect. Breakthrough in solar cell development technology. Collectors are a major component of solar energy applications. However, the main drawback of current collectors is the lack of thermal energy storage effect.

4. Feasibility Analysis of the Co-Development of Hydrogen Energy and Solar Energy

4.1. Analysis of Complementary Advantages and Disadvantages

4.1.1. Hydrogen energy

At present, people agree that hydrogen energy is a clean energy. As an ideal new energetic energy, it has several advantages. Hydrogen has good thermal conductivity, which is higher than that of most gases. The reserves of hydrogen energy are abundant. It mainly exists in water, and water is the most widely distributed substance on the earth. Hydrogen energy can be recycled. The waste from hydrogen energy vehicles is water, which can be recycled. The heat generated by the combustion of hydrogen energy per unit mass is very high, which is the highest heat generated by all fuels except nuclear fuel. Hydrogen energy is widely used. It can generate mechanical energy in the heat engine for driving the vehicle; it can be burned to generate heat energy for heating, etc. [8, 9].

It is undeniable that hydrogen energy has many advantages, but it also has certain disadvantages. The cost of using existing technologies to obtain hydrogen is much higher than that of other new energy sources. Electrolysis and steam reforming are two indispensable processes for hydrogen production, and the cost of realizing these two processes is very high. That's why hydrogen energy has not been widely used. Hydrogen energy is difficult to store and transport and its density is very small, which means that it must be compressed into a liquid and stored at a low temperature to ensure that hydrogen can still function effectively after reaching the destination. The safety of hydrogen energy cannot be guaranteed. Hydrogen is flammable and volatile. Compared with other gases, hydrogen has no odor and is difficult to detect leakage. Production of hydrogen fuel requires fossil fuel [9].

4.1.2. Solar energy

Solar energy is renewable energy, which is mainly represented by the sun's rays. Solar energy has several advantages. Solar energy is widely distributed around the world, and can be directly converted into heat energy, electric energy, etc. for use. At this stage, the storage technology of solar energy is relatively mature. The process of solar power generation will not produce any pollution, and it is recognized as the cleanest energy. Solar energy can be regarded as inexhaustible, as the total amount of solar energy that the earth can receive every year is equal to the energy generated by burning 120 tons of coal.

Solar energy also has certain disadvantages. Solar energy is dispersive. The sun radiates a lot of energy to the ground, but the energy generated by the solar energy received per unit area is not much. In order to achieve a certain power of solar power generation, the requirements for equipment are very high. Solar energy is unstable. Due to the influence of natural conditions, such as weather, the solar energy reaching the ground is unstable, so it cannot be completely dependent on solar energy for power generation, which also increases the difficulty for the further development of solar energy. The efficiency of solar energy is low and the cost is high. Although many solar-related devices, such as solar panels and solar water heaters, have been applied on a large scale, in fact, their conversion efficiency is very low. In the laboratory, the efficiency of some devices is even lower than 30%. Solar panels can cause pollution: solar panels cannot be used indefinitely. If the replaced solar panels cannot be recycled after reaching the service life, they are difficult to be degraded in the natural environment, thus causing pollution.

4.1.3. Comparison of hydrogen energy and solar energy

To facilitate comparison, the advantages and disadvantages of hydrogen energy and solar energy are analyzed together in Table 1. It can be seen from Table 1 that some advantages and disadvantages of hydrogen energy and solar energy are complementary. How to store and transport hydrogen energy safely and effectively is an unsolved problem, while solar energy is ubiquitous; At this stage, if people want to get hydrogen fuel, they still need fossil fuel, but the way to obtain solar energy is pollution-

free; The utilization rate of hydrogen energy is high, while the efficiency of solar energy is low. Therefore, if scientific researchers can put forward a new idea to make the advantages and disadvantages of hydrogen energy and solar energy complement each other, then the problems of single hydrogen energy or solar energy in practical application can be solved.

Table 1. Comparison of advantages and disadvantages of hydrogen energy and solar energy.

	Hydrogen energy	Solar energy
Advantages	good thermal conductivity, rich reserves, recyclable, high calorific value, multiple utilization forms, high utilization rate	universal, without geographical restrictions, pollution-free, large in total
Disadvantages	expensive, difficult to store and transport, its safety cannot be guaranteed, the production of hydrogen fuel requires fossil fuel	dispersion, instability, low efficiency, high cost

4.2. Feasibility Analysis of Complementary Development

The main disadvantages of solar energy are instability, low efficiency, and high cost, while the calorific value of hydrogen energy is high and the utilization rate is high. Therefore, if solar energy is converted into hydrogen energy and used, the defects of solar energy in the application process can be improved. According to the existing technology, the generation of hydrogen energy cannot be separated from fossil energy, while the collection and conversion of solar energy do not require fossil energy, so it will not cause any pollution. If scientists can focus on solar hydrogen production, it will greatly reduce environmental pollution. As a consequence, if the conversion from solar energy to hydrogen energy can be realized, these two energy sources can achieve complementary development.

5. Suggestions

If solar energy is converted into hydrogen energy and stored and transported, some advantages and disadvantages of hydrogen energy and solar energy can be complemented. Solar hydrogen production technology is driven by solar energy, decomposes H_2O to produce H_2 , and H_2O is generated after H_2 combustion. At present, the methods of using solar energy to decompose water to produce hydrogen mainly include solar thermal decomposition of water to produce hydrogen, solar photovoltaic electrolysis of water to produce hydrogen, solar biological hydrogen, and so on. At this stage, solar hydrogen production technology has made considerable progress, but its efficiency is lower than traditional fossil fuel hydrogen production technology, and its cost is higher, so it has not been widely used [10]. Therefore, to realize the co-development of hydrogen energy and solar energy, it is essential to make solar hydrogen production technology widely used.

6. Conclusion

Under the background of "double carbon target", people need to discuss a countermeasure to deal with the current problem of energy depletion. This paper discusses the characteristics, sources and application scenarios of hydrogen energy and solar energy, and analyzes the problems that need to be solved in the application process of these two new energy sources and their future development prospects. Through analysis, it is found that both new energy sources have broad application prospects. This paper compares the advantages and disadvantages of hydrogen energy and solar energy. Among them, hydrogen energy has good thermal conductivity, rich reserves, recyclability, high calorific value, multiple forms of utilization, high utilization rate, but high price; Solar energy is widespread, without geographical restrictions, pollution-free, large in total, but unstable. Through analysis, it is found that if scientists can improve the efficiency and reduce the cost of solar hydrogen production technology, environmental pollution can be greatly reduced. Therefore, continuous improvement of solar hydrogen production technology is the direction of scientists' efforts. Through the extensive application of solar hydrogen production technology, the co-development of the two

can be realized, the energy utilization efficiency can be improved and the cost can be reduced. In the future, researchers should focus on solving the shortcomings of solar hydrogen production technology, improving its efficiency, reducing the production cost of equipment, and realizing large-scale industrial applications. This paper puts forward some suggestions for achieving the complementary development of hydrogen energy and solar energy.

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