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Hydrogen energy—One of the best solutions under the background of energy saving

Duan Qian

Energy and Power Engineering, Anhui University of Technology, Ma Anshan, An Hui, 243000, China

sdyson76350@student.napavalley.edu

Abstract. As the new energy cars are more and more welcome by the society and Chinese government supporting for hydrogen energy continues to increase, those company such as TESLA and BYD, two typical electronic car producer, are taking the main part of family use cars. In the future, hydrogen energy batteries will be put into all aspects of life, and it will also play an important role in the development of new energy. Making full use of hydrogen fuel cell plays an important role in promoting China's national defence science and technology and economic life. Under the impetus of FCH JU, the EU is preparing to enter the market on a large scale and accelerate the implementation of demonstration operation projects. At the same time, the large-scale use of hydrogen fuel cells brings less carbon emissions to the EU, and energy efficiency will increase by 27% in the next 10 years.

Keywords: Energy, Fuel Cell, Carbon emission

1. Introduction

Under the dual-carbon goal, the transformation of traditional energy has become inevitable. However, in the overall trend, coal as the pillar of China's traditional energy, it provides a security guarantee for the development of our country [1].

The coal will still be the main body of energy in our country. Due to the large reserves of coal in China, at present, no energy can replace coal from the root as the backstop guarantee role and main position in China's energy system. The trend of increasing coal consumption will not change. Although the state implements the "double control" policy for coal, according to the relevant legislation, the national production of coal is controlled at about 4.1 billion tons by the end of 2021, and the annual consumption is about 4.2 billion tons. By 2030, coal consumption could reach up to 4.5 billion tons. It can be seen that the consumption of coal is still showing an upward trend. Coal's status as the most economically secure energy source will not change. Compared with new energy, coal has been used as an energy source for more than 100 years, and the technology is mature. According to the measurement, the ratio of coal, oil and natural gas with the same calorific value is 1:7:3, which shows the high cost performance of coal.

Energy structure changes. China's energy structure is changing from the traditional coal as the main or even the only energy to a variety of energy complement each other's advantages and disadvantages. The situation of the simultaneous development of clean energy concentration and divergence in China

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is gradually taking shape, and the domestic foundation of new energy is not strong enough, and traditional energy needs to complement it [1].

Compared with the traditional scheme, the multi-parameter control scheme using both the pump and the fan can stably and efficiently maintain the coolant temperature at the inlet and outlet of the reactor, and the response speed is faster and can be dynamically adjusted, making the efficiency of the battery stack higher [2]. China is a country with reach energy storage, especial the fossil fuels. In 2022, 1.3billion tec were consumed, which the traditional energy consumption charge 90% of total [3]. The emission from Chinese transportations takes 12% of total Chinese carbon emission. With the using of new energy vehicles may significantly improve the problem of excessive emissions [4].

The existing energy storage methods can be divided into electrochemical energy storage, physical energy storage and electromagnetic energy storage. Among them, electrochemical energy storage is mainly stored in chemical ways such as battery energy storage and supercapacitor energy storage. Physical energy storage includes pumped storage flywheel energy storage and so on. The typical rated power of supercapacitors, flywheel energy storage, and superconducting energy storage is very small, but it has a high specific power and a very short response time, so it can support large current discharge, which is suitable for coping with various sudden situations and can improve the power quality of users. Pumped storage, compressed air energy storage, lead-acid batteries, sodium-sulfur batteries, all-vanadium flow batteries and lithium-ion batteries not only have a large typical power, but also can provide several hours of electrical energy output time, so it is suitable for large-scale energy storage systems such as system peak balancing, large-scale emergency power supply [5].

2. Method

2.1. Hydrogen energy is a trend of future development

Apart from traditional battery charging ,hydrogen cell is one of the future tendency. Hydrogen got higher energy density at the same mass. Also, the use of electrolytic hydrogen energy storage has the advantage of energy storage. With the develop of technology, the photovoltaic and wind power costs will be lower in the near future. Hydrogen energy storage can be achieved when the hydrogen production efficiency is improved and the hydrogen storage pressure reaches 60mpa. In the field of new energy vehicles, hydrogen fuel cells can also effectively improve the endurance of vehicles [6]. Compared with the traditional centralized power supply, the fuel cell distributed power supply system is smaller in scale and is not subject to regional restrictions, which can provide solutions to the difficult and inconvenient power supply in remote areas [7].

Table 1. Two different backup power systems in equipment procurement costs, system operation and maintenance costs and other costs [7].

Backup power scheme	**Battery pack with mobile oil machine backup power supply**	**Ethanol hydrogen fuel cell backup power system**
system configuration	100A switching power supply +48v/200Ah storage batteries +5kw Mobile oil engine	Alcohol-hydrogen fuel cell module (48V/50Ah) +LFP battery (48V/50Ah) + monitoring and control unit + power distribution unit
Equipment installation cost (RMB)	44000	204500
Annual maintenance cost (RMB)	3480	1690
Annual electricity consumption (RMB)	5720	340
Fuel usage cost (RMB)	15120	7250

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Table 1. (continued).

Integrated cabinet (RMB)	**800**	**800**
Power cord (RMB)	300	300
cost of labor (RMB)	650	650
Total cost (RMB)	70070	215530

In Table 1, it can be seen that the overall installation and operation cost of the standby power supply system of the alcohol-hydrogen fuel cell at the current stage is higher than that of the traditional scheme.

Table 2. Service life of key equipment in different backup power systems [7].

System type	facility	service life (year)
Ethanol hydrogen fuel cell backup power system	Alcohol-hydrogen fuel cell module	15
	LFP battery	3
	monitoring and control unit	10
Lead-acid battery backup power system	storage battery	3
	diesel engine	8

From Table 2, it can be clearly seen that in the first 3 years of investment, due to the very large cost gap of investment, there is no advantage or even a certain disadvantage in the price of ethanol hydrogen fuel cell backup power supply. However, when the service life is more than three years to six years, the price advantage is reflected. Compared with traditional battery packs, alcohol-hydrogen fuel cells consume less fuel and electricity resources. At the same time, the service life of the traditional battery pack is generally not high, and it needs to be replaced regularly. Therefore, in the longer term, the cost of alcohol hydrogen fuel cells is less than that of traditional energy sources, and the price advantage is more obvious with the increase of use time.

Compared with traditional batteries, alcohol-hydrogen fuel cells have stable performance, safety and reliability, and long power generation duration. This excellent performance determines that the alcohol-hydrogen fuel cell can meet the future market demand and complex operating environment and has a good market prospect. As an alcohol-hydrogen fuel cell using hydrogen fuel as the main fuel, methanol is widely available in nature and easy to obtain, and can be prepared from biomass such as domestic waste, which can alleviate the pressure on environmental protection to a certain extent.

At the same time, the traditional hydrogen energy storage is difficult and complicated, resulting in the high cost and low safety of using traditional hydrogen fuel cells. The alcohol hydrogen fuel cell eliminates the process of hydrogen storage, which greatly reduces the possible safety risks. The energy storage density of alcohol-hydrogen fuel cells is higher than that of pure hydrogen fuel cells. Under normal circumstances, the power density of alcohol-hydrogen fuel cells is only 1/3 of that of pure hydrogen fuel cells.

The traditional standby power system is generally composed of battery packs and diesel engines, which covers a large area, is noisy and polluted. The alcohol-hydrogen fuel cell overcomes these shortcomings and achieves the advantages of small environmental impact and large capacity. At the same time, its power generation efficiency is improved by about 40% compared with traditional diesel engines. Because the substances inside the alcohol-hydrogen fuel cell do not participate in the reaction when it is not working, there is no problem of internal discharge and the service life is long.

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Table 3. Several types of base stations in the following chart:

Type	Characteristic	Application places
Macro Site	The power supply is powered by 48v DC. The current varies according to the actual load quantity and size of the device. The current range of the integrated cabinet is generally 10-50A, and that of the equipment room is 60-100A	Integrated cabinet covering areas such as urban computer rooms, townships, and highways
Micro base station、RPT、distributed base station	Ac 220V power supply, the load is small, easy to install and easy to achieve	High-rise buildings, low shopping malls, hospitals, enterprises and other densely populated occasions.

Overall, in Table 3, the integrated macro base station with lower power is more suitable for alcohol-hydrogen fuel [7].

Table 4. Advantages and disadvantages of three kinds of energy in application.

comparative item	diesel	lithium battery	hydrogen cell
energy density /(w•h•kg^{-1})	11833	160~300	36000
energy conversion efficiency /%	35~45	40~50	60~68
Power system cost /10^{4}RMB	About 3(2 Litre diesel engine includes stageV aftertreatment system)	About 4.5(45kw•h)	About 5.5(100kW galvanic pile + hydrogen storage tank)
Full load 1 hour energy consumption cost /RMB	About 58	About 11	About 12.6
Investment in supporting facilities /10^{4}RMB	About 400	About 430 (Ten an hour to fill the pile)5000 (A three-minute quick fill pile)	About 1000
The average number of cars that can be filled per day is calculated with a medium load of 6 hours	800~1000	50~100	800~1000
Combined discharge	highest (Dispersed emission)	high (Upstream centralized discharge)	low (Upstream centralized discharge)

Table 4 shows that in the field of engineering, the power consumption cost of electric forklifts is lower than that of diesel forklifts, but the purchase cost is higher than that of diesel forklifts. Under the same working conditions, diesel forklifts can work 24 hours without interruption, but traditional battery forklifts need to replace the battery after working for a period of time, resulting in additional costs. The hydrogen fuel cell combines the advantages of both, which can last a long time, and the power consumption cost is low, and the only disadvantage is that the purchase price is too high [8]. In the United States, the retention rate of hydrogen fuel cell forklifts is as high as 3x104 units. From 2012 to

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2020, the annual growth rate is 42%. This shows that hydrogen fuel cells in some application markets is very in line with the needs of users, with the progress of technology, the cost of the decline in China's market prospects are very huge [8].

2.2. Characteristics of hydrogen fuel cells

High energy conversion rate Under the development of science and technology, the current electrical efficiency of most models of fuel cells is between 40%-60%, and because hydrogen fuel cells can use cogeneration system, its comprehensive efficiency can reach more than 85% [9]. Small environmental pollution: Because the reaction product of hydrogen fuel cells is only water, the emission of harmful substances is avoided from the source. However, based on the current level of technology, large-scale production of hydrogen is still extracted from coal and natural gas [10] As a result, emissions of pollutants, although reduced, are still large.

Because the fuel cell uses the principle of electrochemical reaction power generation, there are no moving parts when working, so compared with traditional generator power generation, hydrogen fuel cells have almost no noise during use [9]. Compared with ordinary batteries and lithium batteries, fuel cells can work normally at low temperatures and can be used as an emergency power source [9].

Hydrogen energy is widely available in nature, although the main sources of hydrogen production are natural gas, coal and oil, and hydrogen can be extracted from natural water resources in the future. This has allowed the cost of producing hydrogen to fall and hydrogen to become more competitive in the energy market [10].

3. Result

3.1. The feasibility of hydrogen energy development in China and other countries

3.1.1. Domestic advantages of hydrogen energy industrialization. China's support for hydrogen energy continues to increase. In recent years, China has introduced a series of support policies for the development of new energy, covering macro integration, industry management, scientific and technological innovation, fiscal and tax incentives and other aspects of support policy systems. The establishment of hydrogen energy industrial chain system was accelerated. Now the Yangtze River Delta and other industrial clusters have been initially formed. In recent years, 25 provinces and autonomous regions in China have issued industrial plans on hydrogen energy to accelerate the development of local hydrogen energy enterprises. Positive progress has been made in hydrogen energy technology. At present, the key technologies such as raw materials, fuel cell stacks, systems, and vehicles have been preliminarily mastered in our country, which can realize the localization of key parts and raw materials, and have the power system platform and vehicle production capacity of 10,000 fuel cell vehicles [11].

3.1.2. The disadvantages of hydrogen energy. Hydrogenation detection time is long. Although the hydrogenation time only takes a few minutes, the detection before hydrogenation takes 10 to 20 minutes. This brings the time it takes to refuel once without considering the queue to about half an hour [11]. The price of hydrogen vehicles is high. As a newly developed type of vehicle, hydrogen energy vehicles have high production and research and development costs, resulting in high selling price of the whole vehicle. At the same time, the current stage of hydrogen energy in the transportation stage of high security risks, resulting in high transportation costs, operating costs, and then the cost of hydrogenation is also high. Hydrogenation station construction investment is large, complicated procedures. Although the policies conducive to new energy are constantly promulgated, the approval procedures for the construction of hydrogen refueling stations are still cumbersome at this stage, and the return on investment is long [11].

Hydrogen storage tank is faced with safety problems. At present, the hydrogen storage pressure is generally 35Mpa or 70Mpa, and hydrogen in the environment of 30Mpa, 300℃ or more, will produce "hydrogen embrittlement phenomenon", which corroded the metal, causing cracks leading to the hydrogen storage tank rupture [11]. From Table 5, it can be learned that in the future, hydrogen energy

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batteries will be put into all aspects of life, and it will also play an important role in the development of new energy.

Table 5. China's hydrogen energy and fuel cell industry overall goals [12].

Industrial objective		Short-term target	Medium-term target	Long-term target
	2019	2020 to 2025	2026 to 2035	2036 to 2050
Hydrogen energy as a proportion of total energy	2.70%	4.00%	5.90%	10.00%
Industrial output value (billion)	300	1000	5000	12000
Number of hydrogen refueling stations	23	200	1500	10000
Fuel-cell vehicle (thousand/year)	2	50	1300	5000
Number of stationary power supplies	200	1000	5000	20000
Fuel-cell system (thousand/year)	10	60	1500	5500

3.1.3. The EU's attitude towards hydrogen energy. Based on the application and development of hydrogen fuel cell technology, the European Union established the FCH JU Joint Commitment Program. Under the impetus of FCH JU, the EU is preparing to enter the market on a large scale and accelerate the implementation of demonstration operation projects. At the same time, the large-scale use of hydrogen fuel cells brings less carbon emissions to the EU, and energy efficiency will increase by 27% in the next 10 years. At present, the range of hydrogen battery cars has reached 500km, and it may reach 800km in the near future, and the time of hydrogenation can now reach the refueling time of traditional cars, and the traditional oil vehicles may be eliminated on a large scale [13].

4. Conclusion

Through the cooperation and exchange of FCH JU Joint Commitment Program, hydrogen fuel cells have made significant progress and breakthroughs in key areas, and the life cycle cost has been further reduced, while the reliability, durability and efficiency indicators of fuel cells have been significantly improved. Also, making full use of hydrogen fuel cell plays an important role in promoting China's national defense science and technology and economic life.

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