



# Application and Optimization of Hydrogen Storage Technology in Energy Conversion Management

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## Abstract

With the continuous growth of global energy demand and the increasingly prominent environmental issues, the development and utilization of clean energy have become a focus of attention for countries. Hydrogen storage technology, as an important energy conversion and management method, is receiving increasing attention and application. However, there are still some problems and challenges in the energy conversion management of hydrogen storage technology at present. For example, the cost of hydrogen storage equipment is high, the selection and performance of hydrogen storage materials need to be further optimized, and the safety and stability of hydrogen storage systems need to be improved. This paper analyzes the application and optimization strategies of hydrogen storage technology in energy conversion management. By exploring the types, development status, advantages, and disadvantages of hydrogen storage technology, the definition and main tasks of energy conversion management are elaborated. This paper focuses on the application of hydrogen storage technology in renewable energy integration, power system peak shaving, and other energy storage and applications. Suggestions have been put forward for optimizing hydrogen storage technology in energy conversion management, including technological innovation and research and development, policy support and regulatory formulation, investment and industrial coordinated development, talent cultivation, and international cooperation.

## Keywords

Hydrogen storage technology, energy conversion management, optimization

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## 1. Introduction

With the continuous growth of global energy demand and the intensification of environmental pollution and climate change, the development of sustainable energy and improving energy efficiency have become the focus of attention for countries. In this context, the importance of energy conversion management is increasingly prominent, and hydrogen storage technology, as a clean and efficient means of energy conversion, has received widespread attention. This article aims to explore the application and optimization strategies of hydrogen storage technology in energy conversion management, in order to provide a reference for the development of hydrogen storage technology in China [1].

## 2. Overview of hydrogen storage technology

### 2.1 Types of hydrogen storage technologies

Hydrogen storage technology is a technology that stores hydrogen gas in order to convert it into energy when needed. According to different storage methods, hydrogen storage technology can be divided into physical hydrogen storage, chemical hydrogen storage, biological hydrogen storage, and liquid hydrogen storage. Physical hydrogen storage mainly involves storing hydrogen gas in specific containers, such as steel cylinders, hydrogen storage tanks, etc., through compression or liquefaction. Chemical hydrogen storage is the process of combining hydrogen gas with other substances to form compounds, such as metal hydrides, organic hydrides, etc., and storing them. Biological hydrogen storage is the process of storing hydrogen gas through biological fermentation and other processes. Liquid hydrogen storage refers to storing hydrogen gas in a special container after liquefaction. These hydrogen storage technologies each have their own advantages and disadvantages, such as high storage density and good safety of physical hydrogen storage technology, but the volume of hydrogen storage tanks is relatively large; Chemical hydrogen storage technology has a low storage density, but has good development prospects; Biological hydrogen storage technology has a lower storage density, but it is sustainable. Overall, hydrogen storage technology plays an important role in energy conversion management, especially in the storage and utilization of renewable energy [2].

### 2.2 Current Development Status of Hydrogen Storage Technology

Hydrogen storage technology, as a key link in hydrogen energy utilization, has achieved significant development worldwide in recent years. In China, the development of hydrogen storage technology has also received high attention from the government and enterprises. At present, hydrogen storage technology has made certain breakthroughs in physical hydrogen storage, chemical hydrogen storage, biological hydrogen storage, and liquid hydrogen storage.

In the field of physical hydrogen storage, high-pressure gas cylinders, hydrogen storage tanks, and other equipment have been commercialized, and storage density and safety have been significantly improved. Significant progress has been made in the research of metal hydride hydrogen storage and organic hydride hydrogen storage in chemical hydrogen storage technology, and some technologies have entered the demonstration and application stage. In terms of biological hydrogen storage technology, sustainable production of hydrogen is achieved through microbial fermentation and other means, providing a new development direction for hydrogen storage technology. Liquid hydrogen storage technology has made breakthroughs in liquefaction processes, storage containers, and other aspects, providing the possibility for large-scale hydrogen storage and transportation.

At the same time, there are also certain problems and challenges in the research and application of hydrogen storage technology in various countries, such as low hydrogen storage density, high equipment costs, and safety hazards. To address these issues, researchers are continuously optimizing hydrogen storage technology, increasing hydrogen storage density, reducing costs, and improving safety, in order to promote the application of hydrogen storage technology in energy conversion management.

### 2.3 Analysis of advantages and disadvantages of hydrogen storage technology

Hydrogen storage technology, as a clean and efficient means of energy conversion, has many advantages. Firstly, hydrogen combustion produces fewer pollutants and has a smaller impact on the environment, which helps to achieve low-carbon development. Secondly, hydrogen has a high calorific value and can achieve high energy conversion efficiency. In addition, the storage and transportation of hydrogen is relatively convenient, which can be achieved through compression, liquefaction, and other methods. It can also be transported through pipelines, vehicles, and other means.

However, hydrogen storage technology also has certain drawbacks. Firstly, the storage density of hydrogen is lower and the storage space is larger, which increases the storage cost. Secondly, hydrogen has strong combustibility and poses certain safety hazards. In addition, the production and preparation process of hydrogen is relatively complex and requires high technical requirements.

## 3. Overview of Energy Conversion Management

### 3.1 Definition of Energy Conversion Management

Energy conversion management is a process of utilizing energy efficiently, cleanly, safely, and sustainably

through various technological and policy means in the process of energy production and consumption. Its purpose is to improve energy utilization efficiency, reduce energy consumption and environmental pollution, and promote energy structure optimization and low-carbon development. Energy conversion management involves multiple processes, including energy production, storage, transportation, distribution, and consumption. In this process, it is necessary to comprehensively manage energy markets, energy policies, energy technologies, energy facilities, and other aspects to achieve efficient energy utilization and sustainable development. Energy conversion management is a key link in achieving energy security and sustainable development, and is of great significance for building a clean, low-carbon, and efficient energy system [3].

### **3.2 Main tasks of energy conversion management**

The main tasks of energy conversion management include energy market construction, energy policy formulation, energy technology research and development, energy facility construction, and energy consumption management. Firstly, the construction of the energy market is the foundation for achieving energy conversion management, and it is necessary to establish a sound energy market mechanism to promote the diversified development of energy market entities. Secondly, energy policy formulation is the key to achieving energy conversion management, and it is necessary to formulate scientific and reasonable energy policies to guide the development of the energy industry. Furthermore, energy technology research and development is the driving force for achieving energy conversion management, and it is necessary to strengthen energy technology research and innovation to improve energy utilization efficiency. In addition, the construction of energy facilities is an important guarantee for achieving energy conversion management, and it is necessary to strengthen the construction and renovation of energy infrastructure and improve energy transmission and distribution efficiency. Finally, energy consumption management is the fundamental goal of achieving energy conversion management, and it is necessary to strengthen the supervision and guidance of energy consumption, and promote the clean, low-carbon, and efficient development of energy consumption [4].

## **4. Application of hydrogen storage technology in energy conversion management**

### **4.1 Application of hydrogen storage technology in renewable energy integration**

The application of hydrogen storage technology in the integration of renewable energy is of great significance, especially in solving the intermittent and unstable problems of renewable energy. Through hydrogen storage technology, the electricity generated by renewable energy can be converted into hydrogen for storage for future use.

In terms of renewable energy integration, hydrogen storage technology is mainly applied in the following aspects: firstly, in the power generation process of renewable energy sources such as wind and solar power, due to natural factors such as weather, their power generation has certain intermittency and instability. Through hydrogen storage technology, the electricity generated by these renewable energy sources can be converted into hydrogen for storage to cope with load fluctuations in the power system. Secondly, hydrogen fuel cells are an efficient, clean, and low-emission energy conversion technology that converts hydrogen into electricity. Through hydrogen storage technology, the electricity generated by renewable energy can be converted into hydrogen, which can then be generated through hydrogen fuel cells to achieve efficient utilization of renewable energy. In addition, hydrogen storage technology can also be applied in scenarios such as power grid peak shaving and backup power supply, improving the stability and reliability of energy systems.

### **4.2 Application of hydrogen storage technology in peak shaving of power systems**

Hydrogen storage technology plays an important role in peak shaving of power systems, effectively solving problems such as load fluctuations, and improving power system stability and reliability.

In terms of peak shaving in the power system, hydrogen storage technology is mainly applied in the following aspects: through hydrogen storage technology, excess electricity in the power system can be converted into hydrogen for storage for future use. When the load of the power system increases, the stored hydrogen can be converted into electricity to alleviate the load pressure of the power system. Hydrogen storage technology can be used as a backup power source for power systems. When there is a malfunction or emergency in the power system, the backup power supply provided by hydrogen storage technology can ensure the normal operation of the power system. In addition, hydrogen storage technology can also be applied to power grid peak shaving. Through hydrogen storage technology, electricity with significant load fluctuations in the power system can be converted into hydrogen for

storage to cope with load fluctuations in the power system.

In order to achieve efficient application of hydrogen storage technology in power system peak shaving, the following issues need to be addressed: improving the efficiency of hydrogen storage technology and reducing storage and conversion costs. Improve the reliability of hydrogen storage technology and ensure the normal operation of hydrogen storage systems. Strengthen the application research of hydrogen storage technology in power system peak shaving, develop new hydrogen storage technologies, and improve the adaptability of hydrogen storage technology in power system peak shaving.

### **4.3 Other applications of hydrogen storage technology in energy storage and application**

Hydrogen technology has broad application prospects in energy storage and application. In addition to its application in renewable energy integration and power system peak shaving, it can also play an important role in other fields.

In the field of transportation, hydrogen storage technology can be applied to hydrogen fuel cell vehicles. Hydrogen fuel cell vehicles are clean energy vehicles that use hydrogen as fuel and convert hydrogen into electrical energy through fuel cells to drive vehicle operation. Through hydrogen storage technology, hydrogen fuel can be provided to hydrogen fuel cell vehicles, reducing their operating costs and improving their market competitiveness.

In the field of industrial production, hydrogen storage technology can be applied to energy storage and utilization in high energy-consuming industries such as steel and chemical industry. Through hydrogen storage technology, the excess electricity generated during the production process of these high-energy consuming industries can be converted into hydrogen for storage for future use. Meanwhile, hydrogen storage technology can also be used to adjust the energy structure of these high-energy-consuming industries and improve their energy utilization efficiency.

Hydrogen storage technology can be applied to emergency and backup power sources in both household and commercial fields. Through hydrogen storage technology, emergency and backup power sources can be provided for households and commercial venues, improving the reliability and stability of their energy supply.

## **5. Optimization strategies for hydrogen storage technology in energy conversion management**

### **5.1 Technological Innovation and Research and Development**

Technological innovation and research and development are the keys to improving the performance and adaptability of hydrogen storage technology. In terms of technological innovation and research and development, it is necessary to increase investment in hydrogen storage technology research and development, and support enterprises and research institutions to carry out basic and applied research on hydrogen storage technology. We also need to pay attention to key technological breakthroughs in hydrogen storage technology, such as increasing hydrogen storage density, reducing hydrogen storage costs, and improving the safety and stability of hydrogen storage systems. At the same time, encourages interdisciplinary and interdisciplinary collaborative research to promote innovation and development of hydrogen storage technology. In addition, it is necessary to strengthen the standardization of hydrogen storage technology, formulate and improve technical standards, safety standards, and environmental standards related to hydrogen storage technology, and provide technical support for the application of hydrogen storage technology. At the same time, we need to promote the industrialization and large-scale development of hydrogen storage technology, reduce the application cost of hydrogen storage technology, and improve its competitiveness in energy conversion management. Strengthen international exchange and cooperation in hydrogen storage technology, learn from advanced international technologies and management experience, and improve the international competitiveness of China's hydrogen storage technology. Through technological innovation and research and development, we continuously improve the performance and adaptability of hydrogen storage technology in energy conversion management, and promote the high-quality development of China's energy industry [5].

### **5.2 Policy support and regulatory development**

In terms of policy support, the government needs to formulate corresponding policies to guide and promote the development and application of hydrogen storage technology. For example, the government can formulate tax incentives and provide tax exemptions to enterprises and individuals engaged in the research and application of hydrogen storage technology. In addition, the government can establish special funds to support the research and

application of hydrogen storage technology.

In terms of regulatory development, the government needs to formulate and improve regulations and standards related to hydrogen storage technology and regulate the research and development, production, and application of hydrogen storage technology. For example, the government can establish safety and environmental standards for hydrogen storage technology to ensure that its application does not pose a threat to the environment and personnel safety. At the same time, the government can also formulate industrial policies and market access policies for hydrogen storage technology, guiding and promoting the development and application of hydrogen storage technology.

### **5.3 Collaborative Development of Investment and Industry**

In terms of investment, the government and enterprises need to increase their investment in hydrogen storage technology and promote the research and application of hydrogen storage technology. For example, the government can establish a special fund to support the research and application of hydrogen storage technology. In addition, the government and enterprises can also jointly invest in the research and application of hydrogen storage technology through PPP (Public Private Partnership) and other models.

In terms of coordinated industrial development, the government and enterprises need to promote the coordinated development of the hydrogen storage technology industry chain. For example, the government can guide and promote cooperation and exchange among hydrogen storage technology-related enterprises, and promote the development of hydrogen storage technology-related industries. In addition, the government and enterprises can jointly promote the development and application of hydrogen storage technology by establishing industrial alliances and other means.

### **5.4 Talent cultivation and international cooperation**

In terms of talent cultivation, the government and enterprises need to increase their efforts to cultivate hydrogen storage technology talents and improve their comprehensive quality. For example, the government can establish hydrogen storage technology majors to cultivate hydrogen storage technology talents. In addition, the government and enterprises can also improve the skill level of hydrogen storage technology talents by organizing activities such as hydrogen storage technology training and seminars.

In terms of international cooperation, governments and enterprises need to strengthen cooperation and exchanges with advanced hydrogen storage technology countries and enterprises abroad, and learn from and draw on international advanced technology and management experience. For example, the government can organize a hydrogen storage technology delegation to visit and study abroad. In addition, the government and enterprises can jointly promote the development and application of hydrogen storage technology by establishing international cooperation projects and other means.

## **6. Conclusion**

Hydrogen storage technology has broad application prospects and important strategic significance in energy conversion management. Through technological innovation and research and development, policy support and regulatory formulation, investment and industrial coordinated development, talent cultivation, and international cooperation, hydrogen storage technology has achieved significant results in renewable energy access, power system peak shaving, energy storage and application, and other aspects. However, hydrogen storage technology still faces challenges in terms of hydrogen storage density, cost, safety, and environmental protection. In the future, with the continuous progress of science and technology and the deepening of global energy transformation, hydrogen storage technology is expected to be further developed and optimized.

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