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Investment Estimation and Research Analysis of Compressed Air Energy Storage Demonstration Project

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Abstract: As a new type of energy storage technology, It has the advantages of large scale, low cost, long life, clean and pollution-free, unlimited energy storage cycle, independent of fossil fuels and geographical conditions.It is a long-term large-scale energy storage technology with great potential for development.This paper will take the compressed air energy storage demonstration project as the research object, and carry out investment estimation and research analysis.The economic benefit, social benefit and technical feasibility of the project are discussed.It provides a reference for the promotion and application of compressed air energy storage technology.

Keywords: Compressed air energy storage; Energy storage technology; Investment estimation; Economic benefit; Social benefit

1. Introduction

With the transformation of global energy structure and the rapid development of new energy power generation, As an important means to solve the instability and intermittency of new energy generation, energy storage technology has been widely concerned and applied.As a new type of energy storage technology, compressed air energy storage has many advantages, and has become one of the current research hotspots. In this paper, the investment estimation and research analysis of compressed air energy storage demonstration project will be carried out.It provides a reference for the promotion and application of compressed air energy storage technology[1].

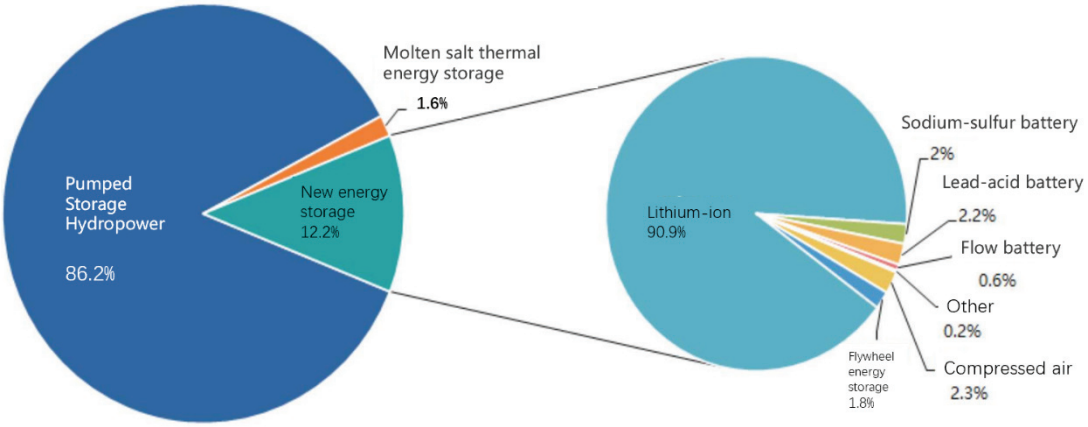

Figure 1. Cumulative installed capacity of global energy storage market (2000-2021)

2. Overview of Compressed Air Energy Storage Technology

Compressed air energy storage (CAES) is a low-cost and large-capacity energy storage technology for electric energy storage through compressed air.It is one of the few ways to store electricity that can achieve hours and hundreds to thousands of MW.The concept of compressed air energy storage technology first appeared in 1949.Stal Laval suggested that compressed air could be stored in underground caverns for energy storage.Compressed air energy storage technology has gradually attracted people's attention.The traditional compressed air energy storage technology consists of a compression unit, an air storage chamber and an expansion power generation unit.During energy storage, the air is compressed to a high pressure state by the compression unit under the drive of the motor and then enters the air storage chamber for storage; When the energy is released, the high-pressure air in the air storage chamber enters the combustion chamber to be mixed and combusted with the mixed gas, The high temperature and high pressure mixed gas formed after combustion enters the turbine to drive it to do work and

drive the generator to generate electricity.In order to realize the high-pressure storage of air, the traditional compressed air energy storage system sets the air storage chamber in the salt cavern hundreds of meters underground.In order to improve the energy storage efficiency of the system, it is necessary to introduce natural gas supplementary combustion in the process of energy release, which is similar to the process of gas-fired power generation.But the difference is that the compression and expansion processes of the compressed air energy storage system operate independently at different times.There is no air compressor to consume the shaft work from the turbine [2].

In recent years, China has also done a lot of theoretical and practical research on compressed air energy storage, and has built a series of demonstration projects.In 2016, the Institute of Engineering Thermophysics of the Chinese Academy of Sciences completed a 10 MW/40 MWh compressed air energy storage project in Bijie, Guizhou Province.The gas storage volume is 600m^3 and the system efficiency is 60%. The Institute of Physical and Chemical Technology of the Chinese Academy of Sciences, Tsinghua University and China Electric Power Research Institute successfully developed the first set of 500 in China in Wuhu, Anhui Province.The invention discloses a kW-level non-afterburning adiabatic compressed air energy storage system, The expansion unit is a three-stage turbo-expander developed by the Institute of Physical and Chemical Technology of the Chinese Academy of Sciences.The designed energy storage efficiency of the system is 41. 5%, and the actual average energy storage efficiency is 22. 6%.The low energy storage efficiency in the actual test is mainly due to the large increase in the actual power consumption of the compressor unit caused by the unsteady compression in the energy storage process.In 2020, China Salt Group, Tsinghua University and Huaneng Group jointly built a 60 MW/300 MWh non-afterburning compressed air energy storage system in Jintan, Jiangsu Province.Abandoned salt caverns are used for gas storage, with a design efficiency of 60.7%, and the project has been put into operation in May 2022 [3].

Compressed air energy storage technology is a kind of energy storage system based on gas turbine technology.The electric energy is stored by compressing the air at the time of low power consumption, The storage and release of energy are realized by releasing high-pressure air to generate electricity at the peak of power consumption.Compressed air energy storage technology is divided into traditional compressed air energy storage and new compressed air energy storage.

The traditional compressed air energy storage system relies on fossil fuels and large air storage chambers, and the system efficiency is low.And that storage and conversion process introduce new pollution.The new compressed air energy storage technology advances through adiabatic compressed air energy storage, liquid air energy storage and supercritical compressed air energy storage.It improves the wide application of compressed air energy storage and makes it have greater development potential.

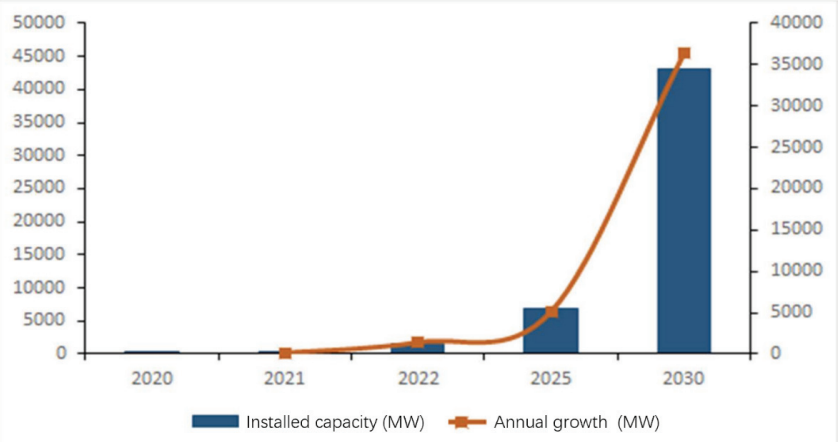

Figure 2. Cumulative installed capacity of domestic compressed air energy storage market (2020-2030)

According to incomplete statistics, the new installed capacity of compressed air energy storage in China will exceed 1600 MW in 2022, showing a large-scale multi-point explosive growth.It is estimated that the installed capacity of compressed air energy storage in China will reach 6760 MW by 2025 and 43150 MW by 2030.Between 2022 and 2025, the penetration rate of compressed air energy storage in new energy storage installations is expected to reach 10%; The penetration rate is expected to reach 23% between 2026 and 2030. Compressed air energy storage is entering a period of large-scale and rapid development.

3. Investment Estimation of Compressed Air Energy Storage Demonstration Project

3.1 Project Overview

The project site is located in a certain area with superior geographical location and complete facilities.The construction period of the project is 24 months, and the total installed capacity is 100MW.

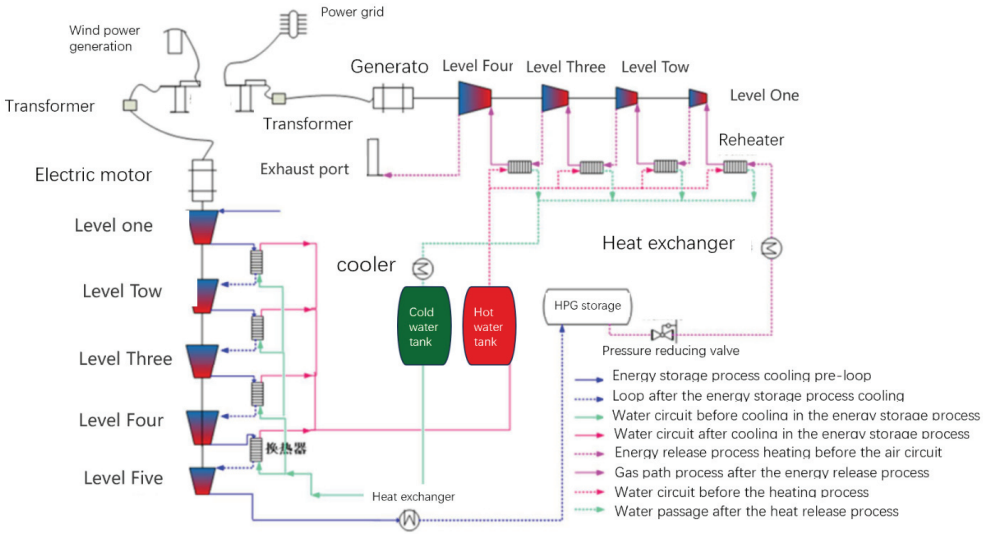

Fig. 3 Diagram of 100MW compressed air energy storage system

When storing energy, the motor drives the multi-stage compressor to compress the air to high pressure and store it in the underground salt cavern.The conversion from electric energy to air pressure energy is completed, and the storage of electric energy is realized.In the process, the compression heat of each stage of compressor is recovered by the heat exchanger and stored in the heat medium water, The high-temperature water after heat recovery is stored in a hot water tank.When releasing energy, the compressed air is released from the underground salt cavern and enters the multi-stage turbine to expand and do work, thus completing the conversion from air pressure energy to electric energy.In the process, the high-temperature water from the hot water tank is introduced into the pre-stage heat exchanger of each stage of the expander to heat the inlet air of each stage of the expander, The low temperature water after heat release is stored in the cold water tank. The compressor of this project can meet the requirements of gas storage after running for 8 hours.The scale of gas storage can meet the requirement that the expansion power generation system can generate electricity for 4 hours under rated working conditions.The operation mode of energy storage system mainly includes shutdown, power generation, energy storage and so on, which has certain flexibility.The operation strategy and mode switching strategy under different modes are realized by software control flow, which can realize one-key start and stop. The software control program is preset in the computer distributed control system of the energy storage power station.

3.2 Investment estimation

According to prudent financial estimation, the total investment of the project is 975.38 million yuan, including 750, 000 yuan of initial working capital.The dynamic investment of the project is 974.63 million yuan, including 23.75 million yuan of loan interest during the construction period.The static investment of the project is 950.88 million yuan, of which the construction cost is 203.62 million yuan, accounting for 21.41% of the static investment; Equipment purchase cost: 405.68 million yuan, accounting for 42.66% of the static investment; installation cost: 178.84 million yuan, accounting for 18.81% of the static investment; Other expenses: 162.74 million yuan, accounting for 16.98% of the static investment.

3.3 Analysis of investment composition

- Construction investment: including project cost, other costs of project construction and reserve fund.
- Interest during the construction period: calculated according to the project loan amount and loan interest rate.
- Working capital: used for daily expenses such as raw material procurement, salary payment, water and electricity expenses during the operation of the project.

4. Research and Analysis of Compressed Air Energy Storage Demonstration Project

4.1 Economic benefit analysis

After the project is put into normal operation, the net profit will be 1, 170.21 million yuan, the financial internal rate of return will be 5.95%, and the financial net present value will be 0.26 million yuan 26889.The total investment recovery period is 12.98 years.

From the perspective of economic benefit analysis, the project has strong financial profitability, good financial net present value and reasonable investment recovery period.The project construction is in line with the national industrial policy and is forward-looking; The technology and process of the project product are mature, reaching the conditions for mass production, and the project product has superior perform-

ance and is a promotional product.

4.2 Analysis of social benefits

The products of this project have a wide range of applications and a large market development space.The establishment of the project has reasonable investment, fast recovery, good market sales, no environmental pollution, good economic and social benefits.It has made positive contributions to local economic development and social progress.

In addition, the promotion and application of compressed air energy storage technology will also help to promote the transformation of energy structure and the development of new energy generation.Reduce dependence on traditional energy sources, reduce carbon emissions and promote sustainable development.

4.3 Technical feasibility analysis

As a new type of energy storage technology, compressed air energy storage technology has many advantages.Uch as large scale, low cost, long service life, cleanliness, no pollution and the like.With the continuous progress of technology and the reduction of cost, compressed air energy storage technology has met the conditions for commercial application.

The construction of this project adopts the most advanced technology scheme in China at present, with reasonable equipment selection and reliable technology.During the construction of the project, the design and construction will be carried out in strict accordance with the relevant national standards and specifications to ensure the quality and safety of the project.

At the same time, the project will actively introduce and absorb advanced compressed air energy storage technology at home and abroad. Strengthen cooperation and exchanges with scientific research institutions and universities, and constantly improve the technical level and innovation ability of the project.

5. Suggestions on the Development of Compressed Air Energy Storage Demonstration Project

5.1 Strengthening policy support

The government should increase policy support for compressed air energy storage technology and formulate relevant policies and plans. Enterprises are encouraged to increase R & D investment and technological innovation to promote the industrialization of compressed air energy storage technology.

5.2 Promote commercial application

Enterprises should actively promote the commercial application of compressed air energy storage technology.We will strengthen cooperation and exchanges with power grid companies and new energy power generation enterprises.Promote the wide application of compressed air energy storage technology in power system peak shaving, frequency modulation and phase modulation.

5.3 Cost reduction

Enterprises should continuously reduce the cost of compressed air energy storage technology through technological innovation and large-scale production.Improve its competitiveness in the market. At the same time, supply chain management should be strengthened to reduce the procurement cost of raw materials and equipment.

5.4 Strengthen personnel training

Enterprises should pay attention to the training and introduction of compressed air energy storage technology talents, strengthen cooperation and exchanges with universities and scientific research institutions, and promote the development of compressed air energy storage technology.Establish a sound personnel training system and technological innovation system to provide talent guarantee for the development of compressed air energy storage technology.

6. Conclusion

As a new type of energy storage technology, compressed air energy storage has many advantages.It is a long-term large-scale energy storage technology with great potential for development.Based on the investment estimation and research analysis of the compressed air energy storage demonstration project, the following conclusions are drawn:

• The project has strong financial profitability, good financial net present value and reasonable payback period;

• The construction of the project is in line with the national industrial policy and is forward-looking. The product technology and process of the project are mature and the performance is superior;

• The promotion and application of the project will help promote the transformation of energy structure and the development of new energy generation.Reduce dependence on traditional energy sources, reduce carbon emissions and promote sustainable development;

• The government should increase policy support for compressed air energy storage technology, and enterprises should actively promote

commercial applications and reduce costs.Strengthen personnel training and technological innovation.

To sum up, the investment estimation and research analysis of the compressed air energy storage demonstration project show that: The project has good economic and social benefits, has the conditions for commercial application, and is worthy of further promotion and application.

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