Research on Energy Storage Technology

Xiang-yu HAN*

North China Electric Power University, China

*Corresponding author

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Abstract. In this paper, three types of electric energy storage technology are introduced, and the comparison of three kinds of large-capacity energy storage technologies is carried out. It is concluded that the electrochemical energy storage technology is more superior in performance and prospect than the pumped storage and compressed air energy storage technologies, with incalculable economic and social benefits.

Introduction

The power industry is a major component of the energy sector. At present, China is heavily dependent on the power supply situation of coal power, which obviously is not conducive to long-term sustainable development. In the "Law of the People's Republic of China on Renewable Energy," our country pointed out that the state has listed the development and utilization of renewable energy as a priority area for energy development and vigorously promoted the establishment and development of the renewable energy market. While storage is the weakest link in the energy sector, it has become a key factor in the development of renewable energy. In fact, with the liberalization of energy markets, many non-localized sources, usually intermittent renewables, will be connected to the grid, which may lead to instability. And in order to overcome this problem, the storage of these energies is particularly important.

Classification of Modern Energy Storage Technology

The current energy storage methods are mainly divided into three categories: mechanical energy storage, electromagnetic energy storage, electrochemical energy storage. Energy storage technology is divided into physical storage, electromagnetic energy storage and electrochemical storage of three categories.

Physical Storage

Physical storage refers to the conversion of electrical energy into kinetic or potential energy storage. Mainly include pumped storage, compressed air storage and flywheel energy storage.

Pumped storage is the use of potential energy and water changes, the power grid when the low load of excess energy into high-value power when the peak power grid.

Compressed air energy storage. When the load is low, the air is sealed with electricity at high pressure (such as underground caves), compressed air is mixed with natural gas when needed, and the combustion expands to promote gas turbine power generation.

Flywheel energy storage is driven by the motor flywheel energy storage, until the design speed, the flywheel by inertia driven generator output power.
**Electromagnetic Energy Storage**

Electromagnetic energy storage is a direct way to store energy in the form of electromagnetic energy technology, including superconducting energy storage, supercapacitor energy storage.

Superconducting energy storage is the energy in the superconducting coil circulating DC current stored in the magnetic field.

The supercapacitor is developed according to the theory of electrochemical double layer. The distance between the two charge layers is very small (usually below 0.5mm). The special electrode material is used to increase the surface area of the electrode by a factor of ten, resulting in a great amount of electricity Capacity, and store the electricity directly in the electric field.

**Electrochemical Storage**

Electrochemical storage is one of the fastest growing energy storage technologies. In addition to conventional battery technologies such as lead-acid and nickel-metal hydride, it also includes large-capacity battery energy storage technologies such as all-vanadium flow, sodium-sulfur and lithium-ion batteries.

In all-vanadium flow batteries, the valence change of vanadium ions is used to achieve the mutual conversion of electric energy and chemical energy.

In the sodium-sulfur battery, the mutual conversion of electric energy and chemical energy is realized by changing the valence state of sodium ions.

Lithium-ion battery is actually a lithium-ion concentration battery.

Comparing the above several energy storage technologies, according to the actual situation of renewable energy power generation, energy storage capacity reached MW level, energy storage time to reach the hour level of large-capacity energy storage technology is mainly pumping energy storage, compressed air storage and electrochemical storage can. Next, the specific application of these three kinds of energy storage technology analysis.

**Comparison and Analysis of Three Large Capacity Energy Storage Technology**

**Pumping Storage**

![Figure 1. Pumping storage.](image)
The structure of pumped storage power plant must have two reservoirs above and below. Its working principle is that during the period of low hydraulic load, the remaining electric energy of the grid will draw water from the downstream reservoir to the upstream reservoir, that is, to store the gravitational potential energy of the electric energy into water; And during the peak load period, the system utilizes the gravitational potential energy of the water stored in the upstream reservoirs to generate electricity, which can supplement the power supply of the power grid.

The pumped storage power station is the only method that can solve the problem of peak valley adjustment in the power system on a large scale nowadays. The pumped storage power station has many advantages: the technology is mature, the operation is reliable and the capacity can be greatly improved. The disadvantage is that the geographical conditions will limit the construction of reservoirs, with appropriate high and low reservoirs, and suitable for the construction of energy storage stations have fewer geographical locations and are generally far away from the load center. Transmission losses are large and the geographically remote locations also bring inconvenience to their maintenance.

**Compressed Air Energy Storage**

![Figure 2. Compressed air energy storage.](image)

A compressed-air energy storage plant is essentially a gas-turbine power plant for peak regulation. Its main principle is to use compressed air remaining in the power grid during periods of low load to store it in high-pressure containment facilities and to release it during peak load and then mixed to drive the gas turbine to generate electricity.

Compressed air storage is similar to pumped storage, and as long as it can be done on a large scale, it can be used to solve the problem of peak-valley difference. The key problem is to find a place suitable for storing compressed air such as underground salt caves, and underground water hole.

![Figure 3. Underground caves.](image)
Electrochemical Storage

All-vanadium Flow Battery

![All-vanadium flow battery](image)

All-vanadium flow battery is vanadium ion valence change, to achieve the chemical energy to the reciprocating conversion of electrical energy in order to achieve the storage and release of energy storage technology. Compared with other energy storage technologies, all-vanadium flow battery energy storage technology has the following advantages: good safety, long cycle life, good charge-discharge characteristics, independent power and capacity design, and environment-friendly for large fixed energy storage power plants. However, all-vanadium flow battery energy storage density is low, larger, energy storage system is more complex.

At present, as an indispensable part of smart micro-grid, all-vanadium flow battery energy storage system can regulate the output characteristics of wind power and solar power in micro-grid to ensure the stability of micro-grid operation. With the large-scale application of renewable energy for the vanadium flow battery provides a broad market space, with the deepening of the power system reform and the introduction of incentive policies, all-vanadium flow battery will usher in the first round of market eruption.

Sodium-Sulfur Battery

![Sodium-Sulfur battery](image)

Sodium-sulfur batteries use sodium and sulfur as the anode and the cathode, respectively. Beta-alumina ceramics function both as a separator and as an electrolyte, storing and releasing electrical energy through valence changes in sodium ions. The theoretical sulfur sodium battery energy up to 760Wh / kg, and no self-discharge phenomenon, discharge efficiency is almost up to 100%.

At present, sodium sulfur battery has been successfully used for the stable output of wind power, and has been very satisfactory stability. The sodium-sulfur battery high specific power and specific energy, low cost of raw materials and manufacturing costs, temperature stability and no self-
discharge and other outstanding advantages, making sodium sulfur battery become the most marketable and application prospects of the energy storage battery.

By comparing the above energy storage technologies, we find that: pumped storage and compressed air storage have special requirements on the geographical conditions, and the application of electrochemical energy storage technology is not subject to site restrictions, performance has room for further improvement, there are more excellent The application prospects.

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References


