

## Research of Smart Grid Energy Storage Technology

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**Abstract.** The application of energy storage technology is equivalent to adding a “storage” effect between the power generation and the power load of the power system, so that the power generation and the power load are relieved and buffered to a certain extent. Therefore, the system is Power quality, stability, and reliable operation can all be significantly improved, and the operation of the power system can be well optimized. On the technical level, by controlling the power exchange device, the energy storage system based on energy storage technology can exchange fast and large-capacity active power/reactive power with the large power grid to maintain the basic balance between power generation and load of the power system, and the power system. The voltage and frequency can also be effectively guaranteed, improve the reliability of power supply and power quality, reduce or avoid the loss caused by grid reliability and power quality problems, and meet the high-spec power requirements of users; in addition, when an accident occurs in the power system, Energy storage technology can help the system to restart / black start, improve the system's rapid recovery capabilities.

### Introduction

At present, under the background of energy structure adjustment, with the inherent requirements of the power system for safe, stable, and efficient operation, the upgrading of existing power systems and the development and utilization of new energy sources are even more urgent. It has prompted the development of China's power grid to enter a new stage - the smart grid. The future smart grid will be a complex of advanced technologies including information and communication technology, power electronics technology, energy storage technology, sensor measurement technology, etc., while energy storage technology is whether the smart grid can be built smoothly. The main support point will play a very important role in the construction of smart grid. The traditional power system follows the pattern of electric energy production-transmission-use during operation. Therefore, the total amount of power generation and the total load and the various losses must be balanced at all times, otherwise it will be It will cause deterioration of power quality, instability of frequency and voltage, and even cause large-scale vicious blackouts in severe cases, posing a serious threat to the safe and stable operation of the power system. At present, the actual demand and operation of China's power system are undergoing profound changes, and many contradictions and problems are gradually being highlighted. The application of energy storage technology is equivalent to adding a “storage” effect between the power generation and the power load of the power system, so that the power generation and the power load are relieved and buffered to a certain extent. Therefore, the system Significant improvements can be made in terms of power quality, stability and reliable operation, and the operation of the power system can be well optimized. On the technical level, by controlling the power conversion device, the energy storage system based on energy storage technology can exchange fast and large-capacity active power/reactive power with the large power grid, thereby maintaining the basic balance of power generation and load of the power system, while power The voltage and frequency of the system can also be effectively guaranteed, improve the reliability of power supply and power quality, reduce or avoid the loss caused by grid reliability and power quality problems, and meet the high-specificity power demand of users; secondly, use the peak-to-valley price difference mechanism The application of energy storage technology can also effectively reduce the load peak-to-valley difference and minimize the construction of rotating spares, thereby achieving economical and efficient energy use.

## Smart Grid with Chinese Characteristics

So far, the smart grid does not have a unified definition on a global scale. According to some international literature, there are mainly the following related definitions.

On the basis of developing an open system and establishing a shared information platform, based on intelligent technology, network sharing and real-time connection between users and users, users and power companies are formed through the use of various electronic terminals. Complete real-time, high-speed, two-way overall effects of data reading, enabling multi-purpose applications such as power, telecommunications, television, remote home appliance control, and integrated charging of battery energy storage systems; at the same time, interactive grids can be integrated into the system. All the data, rationally optimize the management mode of the power grid, and finally build the power grid into a new mode of interactive operation, forming a new service system for the whole grid, greatly improving the reliability, availability and comprehensive utilization efficiency of the entire power system.

It is a highly automated power supply system that monitors every user and node in the system in real time, and the two-way flow of current and information at every point between the power plant and the customer's electrical equipment is fully guaranteed; The application of distributed intelligent devices and broadband communication facilities and automatic control devices fully guarantees the real-time market transactions and seamless connection and real-time interaction between various members of the grid.

By using sensing, embedded processing, digital communications, and IT technology, the smart grid system can centralize the various information in the grid into the power company's processes and systems, making the grid observable (the status of all components in the grid can be Monitoring), control (the state of all components in the grid can be controlled) and automation (with adaptive and self-healing capabilities) to form a more efficient, clean, safe and reliable power system; in short, the smart grid is passed The sensor device is used to connect various devices and assets in the power grid to form a customer service bus, thereby completing comprehensive analysis of information, improving work efficiency, reducing various unnecessary operating costs, and optimizing operation and management of the power grid. Improve the reliability of the entire power system;

## Overview of Various Energy Storage Technologies

Pumped Hydroelectric Storage (PHS) is a mature energy storage method widely used at present. PHS power station has high cycle efficiency (70%~85%), high rated power (10~5 000 MW), large capacity (500~8 000 MWh), long service life (40~60 years), low operating cost, Features such as low self-discharge rate. The location of the power station and the long construction period are the main constraints. At present, the development direction of PHS units is high head, high speed, large capacity and improve the intelligent level of the unit. In addition, Ohio and New Jersey are planning to develop and construct PHS power stations using abandoned iron ore mines. Okinawa has established a seawater PHS power station in Japan, and the United States and Ireland also have plans to build such a power station.

Compressed Air Energy Storage (CAES) has a wide power range (up to 300 MW for large power plants, KW for small systems), high stability, long life (about 20 to 40 years), and low operating costs. 9,10]. The two operational CAES power stations, Huntorf (290 MW) and McIntosh (110 MW), the McIntosh power station structure diagram is shown in Figure 1, the constraints are the power station site selection (using underground cavern gas storage) and the use of fossil fuels and recycling Inefficient (42% to 53%). The newly proposed advanced adiabatic AA-CAES will not use fossil fuels and utilize thermal energy storage to increase overall efficiency. The AA-CAES demonstration project ADELE is being built in Germany with a designed energy storage capacity of 360 MWh, a rated power of 90 MW and a cycle efficiency of 70%. Small CAES using on-ground gas storage facilities are rapidly evolving, such as the compressed air UPS product of PNU Power in the UK. Such systems can be used for backup power, isolated regional microgrids, etc. In

addition, the University of Warwick conducted a preliminary and feasibility study on the direct coupling of wind power to small CAES.

Flywheel Energy Storage (FES) can be divided into low speed FES and high speed FES. Low-speed FES mainly uses steel as the rotor material, and adopts contact mechanical bearings. The rotor speed is less than 10 000 r/min, which is mainly used for short-time high-power discharge and power peak shaving. Due to the high self-discharge rate, low-speed FES is mainly used for short-term energy storage. The high-speed FES rotor material is made of composite material, carbon fiber, etc., with a speed of 50 000 r/min or higher. It needs to rotate in a vacuum-tight environment and use a magnetic suspension bearing, which can be used as a flywheel battery. High-speed FES self-discharge conditions have been effectively improved due to the use of vacuum and suspension technology. Overall, the FES system has high cycle efficiency (85%~95% of rated power), long life (20 years), wide operating temperature range ( $\square$  40~50°C), high energy density and fast response.

### **Application Prospects of Energy Storage Technology in Smart Grid**

The renewable new energy power generation industry is experiencing rapid development. The UK plans to generate about 30% of its electricity production from the new energy power generation industry by 2020; with China's wind power as an example, it is estimated that by 2020, the installed capacity of wind power will exceed 10% of the total installed capacity of power generation. However, there are still important technical bottlenecks in intermittent new energy generation – power generation instability and grid-connected technology issues. The introduction of energy storage technology is the main way to solve the above problems. It can improve the controllability of power plant output power, suppress power fluctuations, improve power quality, and make wind power, photovoltaic power generation and other systems become widely used power supply systems. Energy storage technology selection needs to consider rated power and capacity, response time, safety and stability, technology maturity, and economic cost. From the application point of view, in terms of power quality assurance, flywheels, supercapacitors, some batteries (such as sodium sulfur and liquid flow), superconducting magnetic energy storage systems can make the power output of the power plant smooth, ensure grid power stability; In terms of management, as the installed capacity of new energy sources increases, the capacity of energy storage systems must also increase. New compressed air, thermal energy storage, and some storage batteries (such as lead acid and liquid flow) systems have potential peak shaving functions, which can be adapted to wind power, Large-scale storage of solar power and the like. Some demonstration projects have been built around the world, such as Canada's VRB Power Systems Inc. in the United States, Germany and other places of wind energy storage power grid-connected projects. China is also accelerating its deployment in this area. For example, the running State Grid Zhangbei project (20 MW) is currently the world's largest scenery storage and transportation project. The second phase of Zhangbei Fengguang Storage and Transportation Project began construction in June 2013. These include chemical energy storage devices 50 MW; Nanwang Energy Storage Demonstration Project (10 MW), Shenzhen Baoqing Battery Energy Storage Station (4 MW  $\times$  4h); in addition, the world's largest 5 MW/10 The MWh all-vanadium flow battery energy storage system was connected to the grid in February 2013. After rigorous assessment, it has been fully operational. This technology can effectively promote the popularization of renewable energy in China.

From the perspective of energy storage, in order to achieve short-term power supply, peak-to-peak filling and backup power supply, the energy storage unit system must have the capacity of large capacity energy/power: pumped energy storage is reliable, but needs to be improved for its use. The problem of high investment cost of distributed systems; CAES can also be used for such purposes, and the combined factors of investment and power generation costs can be less than pumped energy storage. In order to suppress the disturbance of the system, maintain the voltage frequency stability and improve the quality of the power supply, the energy storage unit must have a fast response speed (such as ms level) and a certain power output compensation capability: the flywheel energy storage energy density is high, and the response speed is fast. High charge and discharge times, with high potential for application in this area; SMS's ms-level

response speed and appropriate capacity/power output characteristics make it possible to perform such applications well to eliminate system disturbances and maintain grid dynamics Stable, but at this stage SMES has a higher cost investment; battery and supercapacitor technology are also optional, but depending on their characteristics, each has its own limitations or areas for improvement, such as running on distributed generation and micro Lead-acid batteries in grid systems typically have limited charging time/power, which limits their available capacity/power.

## Conclusion

Energy storage technology is an important supporting technology for power system, energy structure optimization and power production and consumption changes. It can provide a variety of practical applications for the future smart grid. At present, energy storage technology is on the eve of explosive development and revolutionary breakthrough. This paper tracks the dynamics and latest information of international energy storage technology development in real time, through the review of energy storage technology, especially the latest development status at home and abroad and its development direction. On the basis of introduction and analysis, the problems that energy storage technology need to solve are put forward. The main reference indicators of energy storage technology in smart grid application are discussed: scale level, technology maturity level, economic benefit, application restriction and environmental protection.

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