A Review on Energy Storage Technology and Its Application in Energy Internet

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Abstract

"Energy storage +energy saving + intelligence" is the future development direction of energy internet. Energy storage technology plays an important role in the energy internet. The typical characteristics of energy based on internet, introduces several key energy storage in internet technology, introduces several typical applications of energy storage technology in the energy internet, such as the peak regulation and frequency regulation, smooth renewable energy fluctuation, improve the quality and reliability of distribution, as base stations, community or family of standby power. The development trend of the internet under the background of energy storage technology and challenges are analysed, pointed out that the new energy power generation and energy storage, energy storage allocation path and energy allocation strategy, energy storage and energy conversion device of the integrated design and coordination configuration, test the trading mechanism considering energy storage is in storage the energy internet application of several key technologies based on.

Keywords

Energy internet, energy storage, electric vehicle, energy transaction.

1. Introduction

With the pollution of the global environment and the depletion of traditional fossil energy, people are paying more and more attention to the development and utilization of clean energy. The energy internet is the integrated use of advanced power electronic technology and information technology, a large number of the distributed energy collection device, distributed energy storage device and various types of load of energy of nodes interconnected, efficient, clean and safe energy use to achieve[1]. The energy internet will solve the problem of large-scale renewable energy power consumption, power balance instantaneous information sent from the root, the local energy system is flexible and efficient and economic operation, energy market transactions and other functions. For the energy storage technology has brought development opportunities, all kinds of reservoir with different technical characteristics for the characteristics of the technology will play an important role in the energy internet, such as the implementation of large-scale energy storage, supporting wide area deployment of energy, energy efficient and flexible application and energy demand are combined to realize real-time response energy demand[2].

The rest of this paper is organized as follows. In Section 2, we introduce the technology of several kinds of energy internet key energy storage. In Section 3, we introduce the Energy storage technology in the typical application scenarios of energy internet. In Section 4, the energy internet storage technology development trends and challenges are analysed and discussed. We finally conclude this paper in Section 5.

2. Energy Internet Storage Technology Classification

Energy storage technology, as one of the most important elements in the energy internet, plays an important role. Energy storage can fundamentally solve the problem of different production and consumption of energy. It translates energy from time and space, and effectively realizes the

interconnection of energy [3][4]. Several energy internet typical energy storage technologies are mainly introduced in this section.

2.1 Mechanical Energy Storage

2.1.1 Pumped Storage Energy

Pumped storage is the most widely used energy storage technology in power system[5]. Its main applications include energy management, frequency control and reserve capacity of the system. The pumped storage power station (Pumped Storage Power Station), combined with solar energy and wind energy, ensures the supply of peak electricity, which is most reasonable in the distribution of electricity. Because the greatest advantage of water power generation is to generate electricity by generating electricity, without generating electricity, and it is easier to start and close the gates.

2.1.2 Flywheel Energy Storage

The principle of the flywheel energy storage is that the electrical energy is converted into the mechanical energy of a rotating object, and then the energy is stored[6]. In the energy storage stage, the flywheel is driven by the motor to accelerate the speed of the flywheel to a certain speed, transform the electrical energy into mechanical energy, and in the energy release stage, the motor acts as a generator to make the flywheel slow down and transform the mechanical energy into electrical energy. The flywheel system running in high vacuum environment, which is characterized by no friction loss, small wind resistance, long service life, impact on the environment, require little maintenance, applicable to the grid frequency and power quality assurance, is currently the most promising energy storage technologies.

2.1.3 Compressed Air Energy Storage

The compressed air in the power grid load trough used for compressed air, the air pressure seal in the abandoned mines, the settlement of the undersea gas tank, caves, oil and gas expired or new gas wells, the release of compressed air in peak load power driven turbine. The compressed air storage power station has many advantages: improving the load rate of the grid, improving the economy, reducing the load fluctuation of the large generator set and improving the reliability.

2.2 Energy Electrochemical Energy Storage

2.2.1 Sodium Sulphur Battery

Sodium sulphur battery works at high temperature of 300℃, its positive active material is liquid sulphur (S), the negative active material is liquid metal sodium (Na), and the middle is porous ceramic separator. Sodium sulphur battery has many characteristics: one is high specific energy; the two is high current and high power discharge; the three is high charge and discharge efficiency, and the current efficiency of charge and discharge is almost 100%. Sodium sulphur battery is a kind of energy storage battery. It can withstand a current of more than 5~10 times the rated power. At the peak of power consumption, it can release the stored electrical energy in a stable power to the grid. The greater role of sodium sulphide energy storage battery is to“ cut peak and fill valley”for the whole power grid.

2.2.2 Energy Storage of Lithium Ion Battery

Lithium-ion batteries are considered to be the most potential power battery systems because of the remarkable advantages of both high specific energy and high specific power[7]. The advantages of lithium ion batteries are light weight, large energy storage capacity, high power, no pollution, long life, small self-discharge coefficient and wide range of temperature adaptation. At present, the main obstacle to the application of large capacity lithium ion power battery is the safety of batteries. That is, the battery is vulnerable to explosion or combustion under the condition of overcharging, short circuit, stamping, puncture, vibration, high temperature heat shock and other abuse.

2.2.3 Storage Energy of Liquid Flow Battery

The active material of the liquid flow battery can be dissolved in two storage tanks[8]. The solution flows through the liquid flow battery, and the reduction and oxidation reaction occurs on the two sides of the ion exchange membrane. This chemical reaction is reversible, so it can reach the ability to

charge and discharge many times. The energy storage capacity of this system is determined by the volume of electrolyte in the storage tank, and the output power depends on the area of the battery. Because both of them can be designed independently, the design of the system is flexible and is limited by the setting of the site. Liquid flow battery has many systems including vanadium, vanadium, bromine, sodium polysulfide, bromine and so on. The electrochemical polarization of liquid battery is small. The vanadium redox flow battery has the advantages of high energy efficiency, large storage capacity, 100% deep discharge, fast charge and discharge, long life and so on.

2.3 Electromagnetic Energy Storage

2.3.1 Superconducting Magnetic Energy Storage

Superconducting magnetic energy storage system (SMES) using superconductor coil made of magnetic energy storage, power transmission without energy conversion form, has fast response speed, high conversion efficiency, large power capacity/advantages, can achieve real-time and large capacity of power system and energy exchange and power compensation. SMES can fully meet the requirements of voltage support, power compensation, frequency regulation, stability and power transmission capacity of the transmission and distribution network. Compared with other energy storage technologies, the superconducting electromagnetic energy storage is still very expensive. Besides the cost of the superconducting itself, maintaining the system low temperature causes the maintenance frequency to increase and the cost to generate is considerable.

2.3.2 Supercapacitor Energy Storage

Super capacitor according to the electrochemical double layer theory developed, can provide a strong power pulse, charging at the electrode surface ideal polarization state, the charge will attract around the ions in the electrolyte solution, which is attached to the electrode surface, the double layer formed, composed of electric double layer capacitor. But the price of super capacitor is more expensive, at present, in the power system for electric load smooth and short time, high power energy quality peak power applications, such as high power DC motor start-up support, dynamic voltage restorer, improve the level of power during the voltage sag and transient interference. Due to the normal work in the full power of the floating state for more than 10 years, so the super capacitor can improve the level of power during the voltage sag and transient interference. Super capacitors are easy to install, small in size, and can run in various environments (hot, cold and humid). Now they can provide commercial services for low power applications.

As can be seen, energy storage technology to system capacity scale and have different performance in the energy density, power density and energy storage, and at the same time, the internet also on storage system of various aspects put forward different technical requirements of application, few can have an energy storage technology can be fully competent in the energy internet a variety of applications. Therefore, the needs of both sides must be taken into account, and the appropriate energy storage and energy supply must be chosen.

3. The Application of Energy Storage Technology in the Energy Internet

Energy storage technology can not only improve the conventional power generation and transmission efficiency, safety and economy, but also realize the smooth fluctuations of renewable energy, peak regulation and frequency regulation, an important measure to satisfy large-scale renewable energy access, but also distributed energy system, the electric car industry an important part, plays an important role in the energy internet[9]. Based on the energy internet architecture, there are two application modes of energy storage in the energy internet, including the application of wide area energy network and the application of local energy network. The main application scenarios include the following aspects.

3.1 Peak Load and Frequency Regulation

The power system peak regulation power needs to follow the force according to the load change to maintain the stability of the voltage and frequency of the power system. The power grid hopes that peak load can be quickly put into and cut out of the system according to the dispatch instruction, and

the output level can be quickly changed according to the instruction. Energy storage technology in improving the ability of peak regulation and frequency regulation grid, can reduce the loss caused by traditional peak regulation and frequency regulation power due to frequent switching; in improving the peak load capacity of power network, according to the changes in the power supply and load, energy storage system can timely and reliably respond to instruction, and according to the instructions to change its output level. Low cost and large capacity energy storage technology is urgently needed to solve the problem of frequency modulation and peak regulation in the field of power grid, so as to improve its power supply reliability and power quality.

3.2 The Power Generation Fluctuation of the Smooth Renewable Energy

The application of large capacity energy storage technology to wind power and photovoltaic power generation can smooth the fluctuation of power output, reduce its impact on the power system, improve the power of tracking plan output of power stations, and provide reserve energy for the construction and operation of renewable energy power stations. The application of high temperature heat storage technology to photothermic power generation can reduce the output instability caused by the instability under the light condition, and improve the dispatching ability of the power station.

3.3 Improving Power Quality and Reliability

The important load of electric power has very strict requirements for power supply reliability and power quality. When the power system fails, backup power is needed to supply power to users continuously, and the power quality problem such as feedback from load to power grid and so on should be prevented. In improving the power supply reliability of distribution network, when a fault occurs in distribution network, the storage system can be used as a standby power supply continuous power supply for the user; in improving the power quality, as the system of controllable power distribution network power quality control, eliminate voltage sags, harmonics and other issues, while reducing the backbone network expansion input and save money.

3.4 As a Base Station, a Community, or a Home Standby Power

Battery energy storage technology is very suitable for use in the field of emergency power supply[8]. With the development of energy internet, it is possible to configure emergency power supply for areas and important electric fields that may be hit by disasters, reduce the occurrence of secondary disasters and improve the overall social emergency capability. Various battery technologies can be applied to the user side. Battery and power electronics technology can provide users with reliable power supply, improve power quality, and make use of the difference between peak and valley price to save users.

3.5 Microgrid Energy Storage

Microgrid can be used as a controllable unit in the power grid[9]. It can respond in seconds to meet the demand of external transmission and distribution network, increase the reliability of local power supply, reduce the loss of feeders, maintain the local voltage, ensure the correction of voltage drop, or provide uninterrupted power supply[10]. The energy storage system has the characteristics of dynamic energy absorption and timely release, as part of the micro grid energy buffer necessary, energy storage system can improve the quality of power network, stable operation and optimization of system configuration, ensure the safe and stable operation of power grid; can also help overcome the problem of small inertia, weak anti-interference ability. It can effectively compensate for the impact of intermittent generation of renewable energy, and make renewable energy output power predictable and schedulable.

3.6 Power Supply System for Electric Vehicle

The electric car is installed to power the safe and fast charging the battery, charging mode selected by the user himself; in the energy station fast charge, slow charge can also be carried out in the parking lot or garage[11][12]. Distributed energy station (Energy Station) is similar to the gas station, power station installed MW the low cost and long service life of the battery can be charged from the grid

storage system, electricity, electric vehicle fast charging station; at the same time, energy can interact with the grid, or for power peak regulation and frequency regulation.

4. Energy Internet Storage Technology Development Trends and Challenges

4.1 Energy Storage Technology Development Trend of the Energy Internet

Energy storage technology not only establishes the coupling relationship among various energy sources, but also provides necessary support for the mechanism and goal of energy internet interaction, openness, optimization and sharing. Energy storage will be an indispensable part of the energy internet construction, and play an important role in energy transfer, matching and optimization in the energy internet[13]. Its development trend mainly includes:

1) The energy internet architecture and operation mode of energy storage, division of internet technology applications. The applicability of various types of energy storage technologies, such as electrochemical energy storage, heat storage and hydrogen storage, in various fields and application scenes are studied.

2) The energy internet energy storage technology will play an important role in power-assisted services, microgrid, distributed generation and distributed generation virtual power plants. The research of energy storage in the impact of pricing and trading of electricity auxiliary services on the economics of energy storage, analyses the competitiveness with traditional methods such as power supply and demand-side management, and evaluates the impact of electricity prices and subsidies on the economics of energy storage.

3) The wisdom of the city, community and other local energy network is the main part of the energy of the internet. The research of energy storage in smart city, community energy supply and other energy internet scene, power storage, cold storage, thermal storage and hydrogen storage and cogeneration matching units such as energy conversion devices, to explore the application of energy storage scheme. Study on operation mode of energy storage.

4) In the trend of power system reform, we will study the possible changes in energy supply mode and business operation mode, analyse the factors that influence the application of energy storage market, and study the demand for foreign energy policy and market environment of energy storage technology.

4.2 Energy Storage Technology Development Trend of the Internet

The large scale application of energy storage technology in the energy internet still has some challenges, including the following aspects:

1) Technical challenges. The maturity of most of the energy storage technology remains to be improved, especially the key materials and core technologies. In addition, energy storage in power grid system is applied for a short time, and the power grid has high safety and reliability requirements. The storage cycle period of energy storage equipment needs to be verified for a long time.

2) Economic challenges. Investment and maintenance costs closely linked to key technologies, energy efficiency and applications will be the key considerations for the development of various energy storage technologies.

3) Policy challenges. Although all countries have formulated the strategy of developing energy storage technology, how to manage energy storage system and how to support the development of energy storage technology still need policy refinement.

5. Conclusion

In the energy internet, energy storage technology in the new energy power generation, improve the flexibility and stability of energy internet, multiple support system optimization and path of energy and energy management, improve operation economy of power network and play an important role in promoting energy trading mode change. The development trend of the internet energy mainly concentrated in the energy internet architecture and operation mode; energy storage in power

ancillary services, microgrid, distributed generation, large-scale new energy power generation and the role of local energy network; energy supply mode and commercial operation mode.

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