

Demand and Application of Energy Storage Technology in Renewable Energy Power System

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Abstract

With the depletion of fossil fuels and concerns about haze issues, renewable energy is gradually entering the field of view. This is a reliable way to solve current environmental problems and an effective way to reduce carbon emissions. However, as renewable power generation has volatility, as the proportion of renewable energy power generation will increase, it will also bring challenges to the existing power grid system. The use of energy storage technology can be used as an effective way to solve the problem. This paper briefly introduces the characteristics of several energy storage technologies and their application status. It analyzes the function and advantages of energy storage devices in renewable energy power plants. Finally, the application model of energy storage system in renewable energy is summarized.

Keywords: Renewable energy; Energy storage technology; Power system.

1. Introduction

Hans Christian Ørsted found the electromagnetic effect, and Edison invented the bulb, we have used electric products from the once luxury, to now necessities of life. Electricity has also become an indispensable source of energy. Over the past more than 200 years, electricity has become a necessity for people's daily life. Electric energy is secondary energy, is through a primary energy conversion. In primary energy, the depletion of fossil energy and the combustion of waste gas have made people pay more attention to the exploitation and utilization of renewable energy.

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Generally speaking, renewable energy mainly includes water power, wind energy, solar energy, biomass energy, tidal energy, ocean energy, geothermal energy and other [1], In addition to the water power, the water can be stored in dam and dam can be repaired so as to ensure the continuity of the power supply. Others, such as wind power, depend largely on the climate, season and other conditions in the area where the power plant is located, and it does not guarantee the stability of the power supply. It is called intermittent renewable energy [2]. With a large number of wind power and photovoltaic power generation equipment as a distributed power supply access, it will affect the synchronous stability of the grid. In the past, electricity was considered to be unsustainable, and the process from power generation to electricity was formed in a small period of time. Therefore, if the energy storage equipment is connected between the power plant and the power system, it will be used as a “Transfer station”. Storing electrical energy in the form of chemical energy, kinetic energy, etc., and converting it into electricity when needed, will greatly change the structure of the grid. For thermal power plants, it is possible to conserve fossil fuels for power generation to reduce waste during periods of electricity consumption. In order to meet the continuity and safety requirements of power supply, distributed energy stations often use energy storage equipment technology.

2. Classification of Energy Storage Technologies

The current commonly used power storage technology can be broadly divided into the following categories: Mechanical energy storage, electromagnetic energy storage, battery energy storage, hydrogen storage energy [3~4], as shown in figure 1:

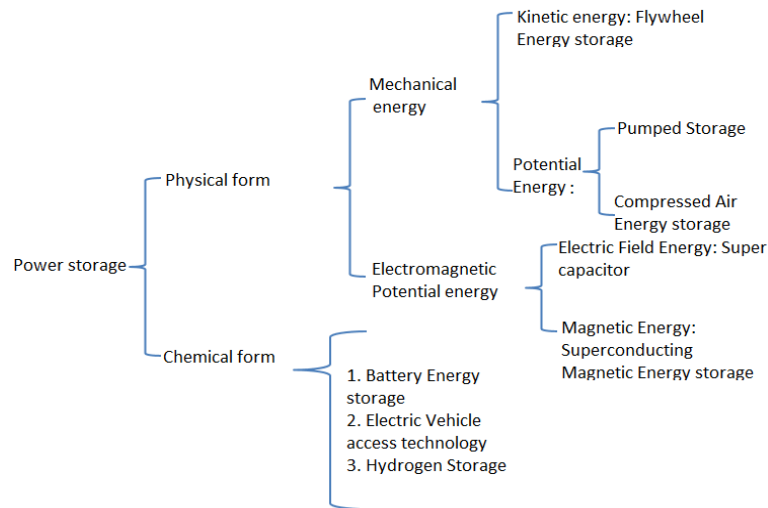


Figure 1: Classification of Energy Storage Technologies

Based on the development situation of the existing energy storage technology shown in Figure 1, this paper briefly introduces several representative energy storage methods.

2.1 Pumped Storage

Currently the most used energy storage technology is pumped storage, the most mature and economically

suitable mode of energy storage, and the conversion efficiency is higher, about 75% [5]. The process of pumping storage is to store the water from the lower reservoir into the upstream reservoir during the trough of the consumption of excess energy; during the peak period of power consumption, the gates of the upper reservoir are opened, water released and used to generate electricity. However, the commonly used pumped storage power stations can be divided into the following categories according to the type of construction and the unit type, as shown in figure 2:

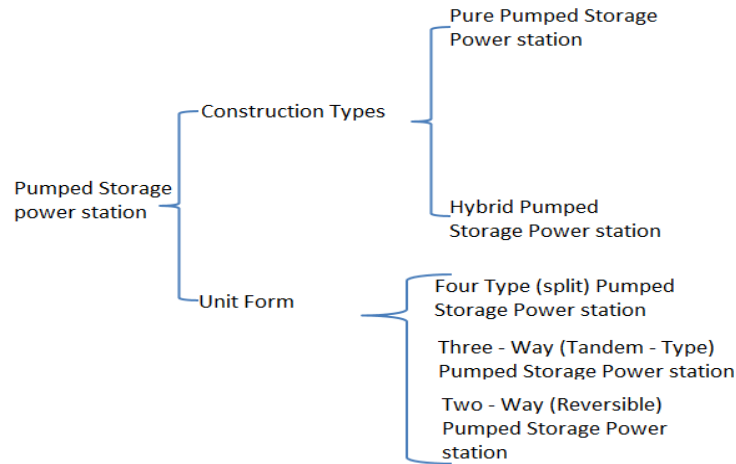


Figure 2: Classification of Pumped Storage Power Stations

In addition, the region for the pumped storage power station is also very important, site should be selected on the basis of large load changes, large electricity consumption, adequate water resources. Pumped storage power stations in China have been used for many years, and the current construction technology is relatively perfect, and the development and use of technologies are also improving.

2.2 Super Capacitor Energy Storage

The super capacitor has two kinds of capacitors, electrochemical capacitor and double layer capacitor. The most widely used capacitor is the double layer type. The schematic diagram of the capacitor is shown in Figure 3, [6]:

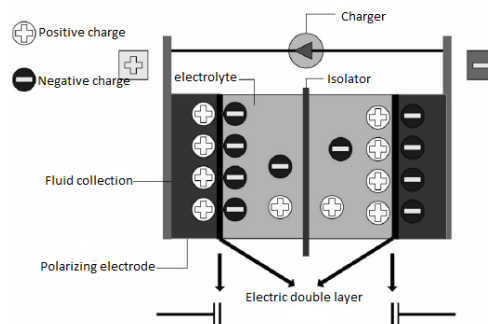


Figure 3: Super Capacitor Schematic

An electrolyte is filled between the two non-metallic plates and a metal spacer plate is added to the electrolyte. Therefore, when the capacitor charges, the electrode surface will attract the neutral ions in the electrolyte and be adsorbed on the surface of the polar plate. The electrode and electrolyte form a double-layer capacitor, and the opposite charge is responsible for the charging of the capacitor. The distance between the two capacitors is very small, and the capacitance structure is special. During the process, the capacitance can reach several hundred times of the common capacitance, and the power density is much better than that of the common energy storage battery. Although super capacitors have many advantages, they also have some defects. For example, the monomer voltage is low, and several super capacitors must be connected in series to meet the application requirements in [7].

2.3 Hydrogen Storage

As the main energy storage mode of renewable energy, hydrogen storage energy is generally used as a "Hydrogen-Electricity-Hydrogen" recycling. The principle is to produce H₂ and O₂ through electrolysis water. When the wind power is enough and cannot get on the Internet, the excess wind power is used to generate H₂ through electrolysis water. When the electricity is needed, the H₂ is released and converted into electric energy.

2.4 Battery Energy Storage

The storage battery is a battery used in the new energy, mainly wind power generation technology compared to other techniques for their low cost, technology is relatively mature, is now the most widely used form of energy storage, can be seen from figure 4 the battery energy storage in the form of storage now occupies a considerable proportion.

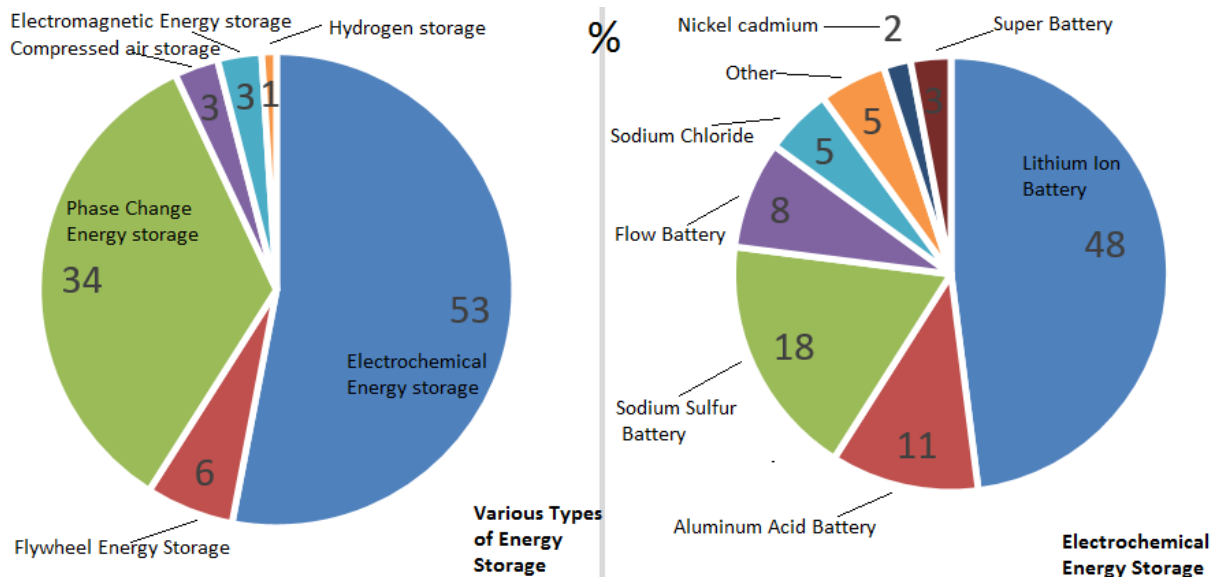


Figure 4: Existing Energy Storage Type %

2.5 Energy Storage of Electric Vehicles

The energy savings of electric vehicles as a cube and secondary energy caches are the central idea of electric vehicle energy storage. When the power grid load is too large, the electric energy saved by the electric car is provided to the grid, and when the load is low, the surplus energy is stored to reduce the loss of energy. According to this form, when the electricity price is relatively low, the electric car users buy electricity from the grid, and when the electricity price is relatively high, they can also sell to the power grid, and derive corresponding benefits.

As the electric vehicle charging, it will greatly increase the load of the grid, and bring a little impact to the power grid. Therefore, we should pay attention to the capacity and location of the charging station, but also pay attention to the characteristics of the discharge, so we need to improve the charging station specifications and grid connected role in order to ensure maximum benefits.

3. Application of Energy Storage Technology in Renewable Energy Power System

One of the most important principles of power grids is that they always meet the power requirements and equal the electricity consumption, the fluctuation of the network load leads to the dynamic balance between the power generation level and the power load, namely the stability of the grid, and the grid itself does not store any power. Today's power grid does not have the flexibility to transmit a large amount of scattered and diversified renewable energy. These two features of renewable energy directly impede the integration of new energy into the grid. In March 2016, the guidance issued by the National Energy Administration 'Guiding Opinions on Establishing the Guiding system for the Development and Utilization of Renewable Energy Resources' further strengthened the position of renewable energy in China's power system. In the future power system, wind power, solar energy and other large-scale access to renewable energy power generation technology will become the main trend of the future development of power grid. In the face of severe restriction of environmental protection of power system, Research and development of new energy storage technology has become an important trend. This critical technology is due to the uncertainty of renewable energy sources, access to the grid for the operation of the existing power system has brought a very challenging problem. The current application of energy storage technology mostly involves:

- (1) The Energy Storage Equipment is arranged on the Power Supply Side: The discharge is carried out according to the dispatching plan, and it runs under certain conditions, it Increase the economics, stability and predictability of renewable energy generation.
- (2) The Energy Storage equipment is arranged on the System Side: Reduce the peak power consumption, raise the trough of power consumption, and change the load accordingly, Voltage regulation, improve the power quality and other capabilities, increase the control function of the system itself.
- (3) The Energy Storage Equipment is arranged on the Load Side: According to the energy storage characteristics of electric vehicles, a fictitious power station is established to control renewable energy Source power generation [9].

3.1 Application in Centralized Large-Scale Wind Farm

According to the application of wind power generation, the energy storage device can effectively improve the voltage and power stability of wind power plants, while regulating and controlling their useful and useless work [10]. When peaking power is configured, the consumption and acceptance level of the local power grid can be increased. When the power supply side is configured, it can be adjusted by means of savings, energy side and user interaction.

3.1.1 Stabilizing Power Fluctuation of Wind Farm

The energy storage system is installed at the grid outlet of the wind farm. The energy storage and discharge function of the energy storage system are used to control the power fluctuation caused by the instability of the wind power [11]. In order to reduce the impact of wind power on the power grid, it is generally installed back-up battery for each typhoon equipment, and its power is 4% of the fan power. In addition, in case of emergency damage to fan blades, a set of batteries with a power of 1% of the fan power should be configured to ensure safety. However, the requirement of the stability of wind power output has become a topic of widespread concern. Because of the rapid development of wind power, the relationship between wind power and power grid is becoming more and more close. If wind farms are required to have the ability to peak and fill valleys, this will require the provision of dynamic energy storage batteries, and its power is roughly about 45% of the rated power of the wind farm; If the fan is expected to be able to power out of the grid, a larger capacity dynamic storage battery should be installed [12].

3.1.2 Suppressing Flicker in Wind Farm

The flicker of wind farm is mainly caused by the rapid change of wind speed and tower shadow effect, although the flicker of a typhoon machine is very small, but when several typhoons merge into a smaller power grid, then flicker is huge. When the wind power is incorporated into the distribution network, the distribution network has relatively large resistance compared to the transmission network, the existing reactive compensation flicker treatment method has some limitations, and when the wind speed is large and the network impedance angle is small, it cannot prevent flicker [13]. Therefore, the problem is solved by accessing the energy storage device at the fan outlet. Normally required energy storage systems should be able to adjust dynamically in milliseconds.

3.2 Application in Photovoltaic Power Plant

The so-called photovoltaic power generation, according to the principle of solar cell, the presence of the photon for electronic transitions, and potential difference, in this way, the solar energy can be converted into electric energy, which is a direct current. The application of energy storage devices in photovoltaic power stations is similar to that in wind farms, When the output power of the photovoltaic cell fluctuates, the energy storage device can operate immediately, providing instantaneous power to ensure that the device can continue to operate stably. Furthermore, the uncertainty of PV output and short-term forecasting errors can be studied according to statistical theory.

In addition, because the battery has a relatively mature technology, high energy density, the price is relatively low, so most of the photovoltaic power station often use battery storage in order to improve the output characteristics of power system, but because of this storage method is very simple, there are defects, such as the use of time is not long, the battery power is relatively small etc. Therefore, some studies have shown that hybrid energy storage systems can be applied to meet the relevant requirements.

3.3 Application in Photo Thermal Power Plant

The difference between photo thermal power generation and photovoltaic power generation is that the solar energy is first converted into heat energy, and then the thermodynamic cycle work theory is used to convert the heat energy into electric energy [15]. Thermal power generation is also alternating current, and it is well adapted to conventional power generation methods and existing grids, so it can be connected to the grid. The biggest difference between the two is that photovoltaic power is the conversion of solar energy into electricity, and the excess power must be stored in batteries. Thermal power, however, can be stored in other energy forms due to the form of heat energy.

Photo thermal power generation is the process of converting solar radiation into heat energy. The technology can be used in two aspects: solar water heaters and photo thermal power generation. Photo thermal power generation has three following technologies: trough type, tower type and dish type [16]. On the theory, energy storage power station can use up to twenty-four hours of uninterrupted power supply, at present, the photovoltaic power generation is also unable to achieve this point, the solar energy has a certain competitive advantage in existing power stations.

3.4 Electric Vehicle Access Technology (V2G)

The core idea of electric vehicle access technology is to link the electric vehicles with the grid, and consider the electric vehicles as energy storage devices, which can play a coordinating role in the grid and renewable energy. Through reasonable scheduling, the charge and discharge of electric vehicle can satisfy the load fluctuation adjustment of power grid to achieve peak and frequency regulation and spinning reserve, and achieve more economic operation mode [17]. For now, only a small number of teams have studied abroad, the most representative of which is a team at the University of Delaware, the team has set up a pilot project in conjunction with the enterprise, which is feasible and economical according to data processing. However, due to the uncertainty of the timing and location of electric vehicles effect the grid. Large number of electric vehicles into the grid will affect the stability and safety of the power grid, and will also affect the quality of power [18]. Relevant researchers at home and abroad have carried out relevant research on it. So far, the main research areas are network/access loss and power quality, in addition, there are research on the orderly charging control of electric vehicles, V2G based power grid planning and scheduling, two-way battery transmission, battery requirements, electricity pricing policies and so on. Because electric cars and new energy sources are all very uncertain, therefore when studying the interaction between them, the ability to reduce the impact of new energy sources on the grid [19], To improve the consumption and acceptance capacity of new energy, the utility model can better improve the cleaning and emission reducing capacity of the electric vehicle.

4. Equivalent Diameter of Leakage Point:

$$d = \sqrt{\frac{4q_m}{3.6\pi\sqrt{2P/\rho}}}$$

Among them for q_m the unit is t / h, estimate the equivalent diameter of the leak. From the experimental results, the data distribution is regular and consistent with the calculation results, in actual production, such accidents as coal economizer leakage should reduce the operation pressure for the first time. As the pressure drops, the leakage will decrease correspondingly. If the amount of drop is in line with the calculation result, the leakage point should belong to a relatively stable situation, the case may be handled through on-site check, such as pressure trap or for shutdown; If the leakage varies, consider whether there are other factors that affect the accident, for such an accident, it should be processed after comprehensive judgment, the emergency shutdown should be initiated in order to prevent the spread of the accident.

4.1 Findings

Based on the simulation software, the equivalent diameter of the boiler economizer leakage point is estimated. If the result of the leakage is proportional to the 0.5th power of the pressure, the leakage area is basically stable, and the equivalent diameter of leakage point can be estimated quickly, the utility model is favorable for handling accidents of operators, and is favorable to cause analysis of accidents, and is favorable to the prevention of accidents, and is beneficial to the safe and economical operation of power plants. In the simulation test, when the coal economizer leakage accident is triggered, the leakage point and leakage amount are judged and Immediately began to drop the load operation. However, as the main valve opens, the steam flow will increase in a flash, the calculation value of leakage is not allowed, and the steam flow and water supply flow are also fluctuated greatly, the stable monitoring data needs a process, and the data recording process is transient, which affects the accuracy in a certain extent, the related research in the future, to further improve the calculation, accurate data, better analysis and treatment of similar accidents. The frequent occurrence leaks cause of four pipe, Therefore, it is difficult to sum up a conclusion through an accident, in the event of such an accident, the operator is prone to make mistakes, bad handling will lead to further expansion of the accident, resulting in irreparable damage to power plants and power grids. To deal with such an accident, we should first learn from its rich theoretical knowledge, especially the causes and corresponding phenomena such accidents, then, through simulation, this kind of accident can be simulated many times, and the law can be found out effectively. The operating personnel's knowledge and mental exercise, to optimize treatment's positive effect, which makes operators can take more reasonable of treatment at the time of the accident, shorten the treatment time, reduce accidents.

5. Conclusion

With the emergence of fog and haze and other environmental problems, renewable energy has gradually been the attention of all parties. Among them, the most important is the energy storage technology in the process of using renewable energy, it affects every link of the "send, lose, match and use" power of renewable energy, not

only can reduce the power supply demand during the peak period of power consumption, but also increase the operation ability and the utilization rate of equipment of the current power grid system; At the same time, it can also ensure the safety and stability of power grid, and then improve the quality of power supply and power consumption, which can achieve economic and social security and stability needs. Now, the energy storage technology has a wide range of characteristics, but it also has defects, such as chemical battery charging less, but also damage the environment; The storage of energy in the form of pumped storage and compressed air requires conversion, making it less efficient, and these forms of storage require substantial construction costs. Therefore, from the current development, in order to make the energy storage device get the best development, and better serve the renewable energy power station, make the power system stable operation, a variety of energy storage devices should be combined to coordinate, control and plan each other. This is also a place for further study.

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