Keywords: Micro energy grid, Energy storage, Energy hub.

Abstract. With the development of energy Internet, the Micro Energy Grid, which includes various forms of energy, including gas, electricity, cold and heat, has developed rapidly. The application of energy storage technology can greatly improve the energy efficiency and reliability of Micro Energy Grid. In this paper, conventional storage technologies such as heat storage, hydrogen storage, electric vehicles and electrochemical energy storage are introduced, and the idea of energy storage technology based on energy hub is put forward.

Introduction

In recent years, due to environmental degradation and energy shortage, the traditional oil, coal and other fossil fuels as the main energy model unsustainable, with strong, interactive, environmental protection, economic as the main features of the smart grid technology is in the ascendant [1]. At present, the concept of energy Internet by the world's universal attention, related industries, technological innovation and large-scale engineering practice have been carried out. China's long-term high pollution, low energy efficiency caused by the production of haze and other environmental problems become increasingly serious. To ensure safe and reliable power supply under the premise of making full use of clean energy and renewable energy complementary features, to enhance the comprehensive utilization of energy efficiency, with great social and economic benefits.

For the industrial park, commercial and residential complex and other objects of intelligent micro-grid has been widely applied. Micro-grid is composed of micro-power and load in accordance with a certain network structure of the system, both with the large power grid and network operation can also be independent of the island mode of operation. The micro power supply in the micro-grid mainly includes distributed power generation unit such as CCHP, wind turbine, solar photovoltaic cell and ground source heat pump, and connecting the distributed power supply into a micro-grid is the future trend of power system One of the intelligent distribution network is an important part [2]. The use of distributed power micro-grid can use a variety of renewable energy power generation characteristics of the different, to achieve a variety of clean energy complementary power generation, improve energy efficiency and reduce environmental pollution [3]. From the current development trend, the distributed power generation needs to solve the problem of abandoning abandoned light, you need to increase energy storage equipment, build Micro Energy Grid.

Micro Energy Grid Concept

Micro energy grid is a micro-integrated energy interconnection system, energy Internet era is a natural extension of the micro-grid. Micro energy grid through a variety of energy grid s (power grid, natural gas network, heat network, transportation network, etc.) interrelated to optimize the design and coordination of operation to achieve more complementary and alternative energy; at the same time local conditions, make full use of local photovoltaic, Geothermal and other renewable energy, reduce the user's comprehensive energy costs, improve energy efficiency, reduce pollutant emissions; meet the end user's gas, electricity, cold, heat and other energy needs, and ultimately safe, reliable, clean
and efficient, Environment-friendly and sustainable development of micro-integrated energy interconnection system [4].

Micro Energy Grid can have the following three advantages: 1) from the energy point of view, Micro Energy Grid can make full use of local renewable energy, and gas, electricity, cold, heat and other forms of organic integration of energy, according to energy prices, The impact of the environment and other factors to a reasonable allocation of regulation in order to achieve multi-energy complementary and alternative energy to enhance the safety and reliability of energy supply system; 2) from the energy service point of view, considering the user's various energy needs, through 3) from the energy grid point of view, through the collaborative analysis of electrical, natural gas, heat and other networks to promote the development of multi-energy technology, through the coupling of each other, the use of energy, Reduce system operating costs, improve the efficiency of the system, and ultimately achieve the sustainable development of energy systems.

Micro Energy Grid as a comprehensive energy system, gas, electricity, cold, heat and other energy coupling with each other, mutual influence, multi-energy energy flow analysis and coordination and optimization of the operation for the system safe and stable operation, reduce operating costs, to achieve alternative And can be complementary to each other is of great significance. However, the current general energy hub model rarely considers the energy storage device, which greatly reduces the flexibility of the model and general-purpose.

**Status of Energy Storage Technology**

In the Micro Energy Grid, the energy storage and energy conversion devices cooperate with each other to maintain the economic and efficient operation of the system. The Micro Energy Grid management system makes decisions on the production and consumption of energy in the LAN according to the state of energy storage and the supply and demand forecast information and the energy price information. From the energy market to buy or sell energy, in the virtual energy plant (VEP) applications, because it is difficult to predict the behavior of the decentralized producers, so the distributed power supply, electric vehicles, such as polymerization management has more Large difficulty, the introduction of energy storage on the management and operation of VEP is of great significance. Under the effect of energy storage, decentralized energy producers have more confidence in the energy supply capacity, so that they have the conditions involved in the energy market transactions.

The traditional meaning of the power storage can be defined as the realization of power storage and two-way conversion technology, including pump storage, compressed air storage, flywheel energy storage, superconducting magnetic energy storage, battery storage and so on. The use of these energy storage technology, the electrical energy to mechanical energy, electromagnetic fields, chemical energy and other forms of storage, and timely feedback back to the power network. Energy The energy storage in the Internet not only includes devices that implement bidirectional conversion of power, but also include unidirectional storage and conversion equipment for power and other forms of energy. In the context of energy Internet, the generalized power storage technology can be defined as one-way or two-way storage devices between power and heat, chemical energy, and mechanical energy.

Figure 1, in addition to energy storage equipment, but also includes the cogeneration unit, fuel cell, heat pump, hydrogen and other energy conversion equipment, energy storage and energy conversion equipment together to establish a multi-energy grid coupling relationship. In the power of energy storage technology under the support of the new energy power generation and combined heat and power units, fuel cells, heat pumps and other conversion equipment to coordinate the operation to achieve the new energy efficiency under the target of energy as the core of multi-energy production and consumption matching.

Energy Internet in the presence of large-scale renewable energy power generation and consumption, local multi-energy system flexible and efficient and economic operation, energy market free trade and other application requirements for energy storage technology provides development...
opportunities. Here are some of the energy storage technologies that meet the development needs of the energy Internet, including heat storage, hydrogen storage, electric vehicles and electrochemical energy storage. Some of these energy storage technologies enable large-scale energy storage. Domain energy deployment play an important role. Some energy storage technologies are flexible and efficient and in close connection with user needs, is a local multi-energy system in the necessary components.

Heat Storage

Thermal storage technology can be divided into significant heat storage, latent heat storage and chemical heat storage 3 categories. Significant heat storage by increasing the temperature of the media to achieve thermal storage. Latent heat storage that phase change energy storage, the use of material phase change when the absorption or release of heat, the current solid and liquid phase change the main [5]. Compared with the sensible heat storage, the phase change energy storage has a relatively stable temperature and a large energy density. Chemical heat storage using reversible chemical reaction storage of heat, can achieve a wide temperature range of cascade heat storage, energy density up to significant heat and latent heat storage more than 10 times [6]. Chemical heat storage technology requires the heat storage medium with a reversible chemical reaction, heat storage material selection is difficult. At present, the heat storage technology is still the main heat and latent heat storage.

Large-scale thermal storage technology in dealing with the elimination of new energy power generation can play an important role. During the winter heating period, in order to meet the heating load, the peak height of the thermoelectric unit is limited. In the high proportion of new energy areas, resulting in serious abandonment, abandoned light phenomenon, for the thermal power unit configuration heat storage device (usually heat storage tank) to a certain extent, can decouple the unit of thermal power and electric power, improve the thermal power unit Operational flexibility and peaking capability. Such as Denmark Avedøre power station installed two sets of storage tanks, the volume of 44000m³, exothermic capacity of 330MJ/s. In the wind power output period, reduce the power generation power station, and the use of heat storage tank to maintain the heat supply, through the electric boiler heating is also one of the means to promote wind power consumption [7]. High-power regenerative electric boilers can be water, steam, solid or phase change material for heat storage.
storage, a single thermal storage capacity of up to tens of megawatt hours. 2011 put into operation in Jilin Datang Tao South wind power heating project is China's first wind power heating project. June 2015, the National Energy Board issued a “on the work of wind power clean heating notice”, and vigorously promote wind power heating technology.

On the user side, the use of low power storage to reduce production and living in the cooling supply cost has become an important manifestation of demand response. The medium used in the storage technology includes water, ice, excellent salt and so on. Ice storage uses water - ice phase change to store the release of cold, the energy density of 335kJ / kg, 7 to 8 times the water storage [8]. Ice storage technology has been very mature, has been widely used. The construction of large-scale refrigeration stations and refrigerant transmission networks to provide cold source to a certain area is the development trend of the technology, the regional cooling technology to promote the peak and valley load regulation has important significance.

Compared to the heat storage, in the same temperature changes, the storage can be more efficient storage of high-grade energy [9]. At present, the deep cold storage technology gradually attention, the use of atmospheric pressure low temperature liquid air for energy storage. In 2011, the world's first set of cryogenic liquid air energy storage demonstration project put into operation, verify the feasibility of cryogenic storage technology. Considering the efficiency of waste heat absorption up to 50%. Unlike cryogenic storage, heat pump storage has a high theoretical efficiency, through the process of heating and expansion of the approximate heat and expansion of gas at the same time produce high temperature heat and low temperature cold energy, in order to achieve the purpose of efficient storage of electricity, reverse the compressed high temperature gas drives the motor to generate electricity. Heat pump storage technology complex structure, the thermal power conversion equipment requirements, only in the small-scale demonstration stage [10].

**Hydrogen Storage**

Hydrogen use involves hydrogen production, hydrogen storage, hydrogen, hydrogen with four links. Natural gas hydrogen production, coal and hydrogen production is the main way of the hydrogen industry. In recent years at home and abroad to carry out the use of new energy power generation electrolysis of hydrogen production of small-scale demonstration projects. Electrolysis of water is a high energy consumption hydrogen method, per cubic meter of hydrogen power consumption of about 4.5 ~ 5.5kW • h, the use of low power grid during the period of new energy power generation hydrogen production is to improve the utilization of new energy sources one of the way. The existing alkaline electrolysis tank and solid polymer electrolysis of water hydrogen technology on the wind power fluctuations have a good ability to adapt. Photocatalytic direct pyrolysis of water is an ideal way to make use of new energy hydrogen production, the key lies in the breakthrough of semiconductor photocatalyst materials [11], the technology is still in the research stage, light capture efficiency and hydrogen production rate cannot meet Commercial demand.

Under the standard state of the hydrogen energy density of only 8.4MJ / L, generally use high pressure or low temperature liquefaction storage, there is energy consumption, poor security and other issues. Hydrogen storage of solid materials is the most promising hydrogen storage technology, can be divided into two types of physical adsorption hydrogen storage and chemical hydrogen storage. The current solid hydrogen storage materials in hydrogen storage capacity, thermodynamics and dynamic performance, reversibility and other aspects to be improved.

The use of existing natural gas pipeline network, the new energy hydrogen mixed into the natural gas pipeline, is to achieve the economic transport of hydrogen energy. Hydrogen and methane have significant differences in energy density, calorific value, and permeability, and the incorporation of hydrogen has a detrimental effect on existing natural gas pipeline facilities. There is no uniform conclusion on the corrosion of hydrogen on pipelines [12]. It is pointed out that when the hydrogen content (volume fraction) is less than 17%, there will not be any significant impact on existing pipelines and terminal facilities. Hydrogen laying dedicated pipes is an effective guarantee for
large-scale hydrogen utilization. In April 2014, the United States from Houston to New Orleans up to 600 miles of hydrogen pipeline was completed.

The fuel cell converts the hydrogen energy into electrical energy using an electrochemical reaction. Proton exchange membrane fuel cell (PEMFC) is the focus of current fuel cell research, suitable for automotive power generation systems and small distributed power supply system. Micro-cogeneration is also one of the important markets for PEMFC applications. In this application scenario, the number of hours of life of PEMFC can be greatly extended due to the lack of frequent start and stop. For power station applications, phosphoric acid fuel cells (PAFCs) can be used as hundreds of kilowatts of power; high temperature fuel cells, including solid oxide fuel cells (SOFC), molten carbonate fuel cells (MCFC) can achieve megawatt-class hydrogen Power generation [13], the world has a number of megawatt fuel cell power plant put into operation.

**Electric Vehicles**

According to the power source, pure electric vehicles can be divided into FCEV and BEV. The former associates hydrogen with the transport network, which will lead to a tight coupling between the grid and transportation. The current BEV has entered the commercial stage, FCEV also entered the commercial promotion stage. The orderly charging of the large-scale BEV and the vehicle to grid (V2G) have a positive effect on improving the operating characteristics of the grid. It is an effective way to realize large-scale electric vehicle and grid interaction by real-time or time-sharing price. It can realize the obstruction management of distribution network, the peak and valley of translation load [14], reduce the electric vehicle Charge the pressure on the grid.

According to statistics, more than 90% of private passenger cars in a state of parking, can be expected to scale the BEV access to the grid constitutes a considerable energy storage resources. The use of electric vehicle energy storage to participate in grid dispatch management, and with the new energy power generation coordination, is one of the prospects for large-scale electric vehicles.

The use of large-scale electric vehicle energy storage capacity has challenged the monitoring, management and control capabilities of power grids [15]. The Danish “Edison” project is one of the few demonstration projects currently using BEV energy storage for grid applications. The project developed the electric vehicle polymerization management software, terminal control software, intelligent charging facilities, etc., the establishment of the electric vehicle and power grid interactive demonstration system. In addition to scattered electric vehicle users, the group is also an important manifestation of electric vehicle energy storage capacity, China in Qingdao Xuejiadao built the world’s largest bus fleet rechargeable power station, 280 buses can be charged for electricity Service, the maximum charge and discharge power of 4320kW.

Electric vehicles as a distributed energy storage unit, the family energy management and distributed power coordination can also play an important role. In the process of electric vehicle marketing, in the smart home, micro-grid and other occasions with other load and power coordination is the current electric car in the power grid in the main application model.

**Electrochemical Energy Storage**

Electrochemical energy storage installation flexibility, fast response, in the power grid for the power service and energy services can play an important role. It has significant technical advantages in restraining the rapid fluctuation of new energy power generation, grid frequency modulation, micro grid energy management and stability support, distributed power supply access and so on. At present, the application of electrochemical energy storage in power systems is growing rapidly. As of the end of 2014, the cumulative total installed capacity of global energy storage (2000 - 2014) reached 845.3MW (excluding pumping, compressed air, heat storage), of which sodium-sulfur battery as a result of early advantage accounted for 40% The battery was rapid growth, accounting for 35%. At present, China has carried out a number of megawatt-class lithium-ion batteries, liquid batteries, lead-acid batteries, super capacitors and other electrochemical energy storage technology demonstration applications. Such as 14MW / 63MW • h lithium iron phosphate batteries, 2MW /
8MW • h vanadium flow battery energy storage units and 2MW / 12MW • h colloidal lead-acid batteries for the development of wind power generation of the adjustable. Shenzhen Baoqing storage power station using 4MW / 16MW • h lithium-ion battery to achieve a variety of distribution network applications. In the off-grid or weak grid connection area, in order to use wind energy and solar energy to provide a stable and reliable power supply, battery storage has been widely used, such as Zhejiang Dongfu Mountain Island wind storage micro-grid project, the project using 100kW photovoltaic, 210kW wind power And 300kW lead-acid battery energy storage to replace the original diesel generator to achieve the island's energy supply. In Germany, Australia and other countries, home photovoltaic power generation has been promoted, due to photovoltaic electricity prices and subsidies continue to cut and the increase in electricity tariffs, making household battery energy with a certain economy.

In addition to the above energy storage technology, the traditional pumped storage, compressed air storage, flywheel energy storage, superconducting energy storage is also an important form of energy Internet energy storage. Due to installation conditions, conversion efficiency and other aspects of the restrictions, which is facing the rapid development of electrochemical energy storage technology competition, energy and Internet applications to meet the needs of the energy storage technology is also constantly evolving. Such as the development of advanced adiabatic compressed air energy storage (AA-CAES) to adapt to the volatility of wind power generation, the development of compressed air storage with the cold and heat triple triple system to improve the integrated efficiency of compressed air storage capacity, the application of modular flywheel energy storage unit Forming the array to improve the flexibility of the system, etc., are not discussed in detail here.

**Energy Storage Technology Development Direction**

In the energy Internet, a variety of energy forms in the most clean and efficient and convenient way to convert, transfer, storage and shared in the client, energy storage and other energy will be flexible conversion and comprehensive use of key equipment. Energy storage to solve the energy production and consumption of the synchronization, so that energy in time and space can be translational, to achieve the premise of energy sharing.

Energy Hub (EH) was first proposed by Geidl.M of the Federal Institute of Technology in Zurich [16], which serves as an energy conversion unit that can meet multiple energy needs and can provide interfaces for input and output of different energy sources at the same time. EH establishes a corresponding coupling model for the power conversion between different energy carriers. From the system point of view, coupling different energy carriers shows many potential advantages over conventional decoupling energy supply networks, and redundant energy flow paths provide A certain degree of freedom provides space for multi-functional co-optimization.

Through the energy hub, you can build gas, electricity, cold, heat and other energy forms of conversion storage, according to the micro-energy grid load demand forecast, to achieve energy economic conversion and efficient storage. The use of energy hub model, you can achieve high-quality energy conversion between the storage, the precise realization of the energy of the cascade use, greatly improving the efficiency of energy use.

**Conclusion**

Energy storage technology not only establishes a coupling relationship between multiple energy sources, but also provides the necessary support for energy Internet interaction, openness, optimization, sharing mechanism and goal. Energy storage will be an indispensable part of the construction of energy Internet, in the energy of the Internet to play an important role in energy transfer, matching and optimization.
References


