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Research on the Extensive Interconnect Characteristics of Power System

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Abstract. Based on the development law of electric energy, this paper puts forward the inevitability of the extensive interconnection of power system and their technical requirements. Firstly, this paper analyzes the law of energy development from the perspective of energy supply development, energy consumption development and energy transaction development. Secondly, based on China's clean energy development pattern, the concept and significance of a new generation of power systems are widely interconnected. Finally, this paper proposes the technical requirements for the extensive interconnection of the power systems, respectively constructs the key technical systems of physical interconnection and information interconnection, and analyzes the development trends of related technologies.

1. Introduction

With the increasingly serious problems of energy crisis and environmental pollution, the main goal of China's energy revolution is to gradually replace fossil energy with renewable energy and promote energy transformation to build a clean, low-carbon, safe and efficient next-generation energy system [1]. Since the power system is closely related to the production, transportation and consumption of renewable energy, the power system plays a key role in ensuring the realization of the core indicators of energy transformation [2]. Promoting the construction of a power system under the energy transition is the main direction in future research. At the same time, with the increase of energy forms, the power system puts higher demands on the extensive interconnection characteristics. Therefore, it's necessary to study the extensive interconnection characteristics of power system, on the basis of technological development and innovation.

2. The law of power energy development

The law of power energy development is mainly divided into three aspects: the law of energy supply development, the law of energy consumption development and the law of energy transaction development.

Fossil energy is the traditional energy source for human survival. It occupies an important position in daily production and life. According to the current mining speed, the annual fossil energy storage-production ratio is generally declining. By 2013, global coal, oil and natural gas can be mined for 113,



53 and 55 years respectively [3]. Although global reserves of fossil energy are large, they are facing the problem of depletion of resources with large-scale development and utilization. At the same time, the emission of greenhouse gases from traditional fossil energy sources exert pressure on the environment. In this context, clean renewable energy has developed rapidly. Renewable energy has gradually occupied a glance of energy production due to its large reserves and high cleanliness. Under the promotion of smart grid development, energy production and the transmission are gradually moving towards low loss. Energy supply shifts from direct, inefficient to indirect and efficient.

Electricity demand is an important component of energy demand and consumption. The continued development of the global economy and the improvement of electrification levels will lead to sustained growth in electricity demand. Per electricity consumption has continued to grow in recent years, and global power consumption growth rate is at a relatively high level. In 2010, due to the slowdown in global economic development, population decline, and per capita consumption, the power consumption showed a negative growth. In the past two years, as the base of power demand has increased, the growth rate of power demand has gradually slowed down. In 2014, the global power demand growth rate reached 3.2%, which is 2.6 times the growth rate of energy demand. The growth rate of power demand is obviously higher than the growth rate of energy demand, and the core position of power in the energy system is gradually strengthened [4].

At present, due to factors such as power transmission capacity of the power grid, power transmission is mainly based on domestic and regional balance, and cross-country power trade is relatively small. Driven by the growth of energy and electricity demand, electric energy as a clean and efficient secondary energy has gradually become an important medium for energy transmission. The UHV power grid will become the backbone of the energy Internet, achieving optimal allocation of energy supply and demand in time and space. The development of the interconnected power grid has achieved the effects of inter-regional peak-to-valley adjustment and mutual backup. Therefore, the configuration of electric energy gradually develops from partial balance to large-scale optimization.

3. The inevitability of a new power system

For the new power system, the main driving force is the change of power structure. In the past ten years, the proportion of renewable energy in China's power system has been increasing, wind power and solar photovoltaic power generation have developed rapidly.

3.1. Analysis of energy development pattern

China's centralized clean energy development pattern is mainly divided into three parts:

(1) Southwest China Hydropower Base. China's hydropower resources technology development capacity is about 570 million kilowatts, mainly concentrated in the southwest, accounting for 82% of the country. By the end of 2013, the installed capacity of conventional hydropower stations in China was 280 million kilowatts, and the remaining capacity was 290 million kilowatts, mainly concentrated in Sichuan, Yunnan and Tibet. In the future, China's large-scale hydropower bases to be developed are mainly concentrated in the Jinsha River, the Yalong River, the Dadu River, the Lancang River, the Yarlung Zangbo River and the Nujang River, with a total installed capacity of more than 260 million kilowatts.

(2) China's "Three North" wind power base. China's 80-meter-high altitude and wind power density of more than 150 (W/m²) have a potential of about 10.2 billion kilowatts. The development potential of wind energy resources above 50 meters in the 5 to 25 meters water depth zone (wind power density ≥ 300 watts/square meter) is about 200 million kilowatts. The "three north" region's wind energy resources account for about 80% of the country's total onshore wind energy resources.

(3) Northwest China Solar Power Generation Base. China's land surface receives annual solar radiation equivalent to 4.9 trillion tons of standard coal. Among them, the Gobi Desert and the desert areas in the western Qinghai-Tibet Plateau, northern Gansu, northern Ningxia and southern Xinjiang have the most abundant solar resources, with a development potential of more than 85 trillion

kWh/year, accounting for 75% of the country's total development conditions, and can build large-scale solar energy. The power generation base sends power to the east China central load center.

Another important form of utilization of clean energy is distributed generation. Distributed energy is generally located on the user side, and meets the user's own needs firstly. It is generally connected to the distribution network, or independently operated, or connected to the distribution network, including an energy comprehensive utilization system for energy generation, storage and control. Distributed energy systems have the characteristics of energy cascade utilization and high efficiency. Due to the small scale, the distributed energy system is mainly for residential users. The development of distributed energy can be a useful complement to the power supply of large power grids.

3.2. *The necessity of extensive interconnection*

The extensive interconnection of the power system is based on the basic characteristics of a power system, to study the new interconnection model of the power grid. The traditional meaning of power system interconnection is mainly for the interconnection of power transmission channels. At present, China's power grid has basically realized the transmission of electricity between regions and regions. Since the biggest feature of the power systems is the change in power supply structure, there is also a new definition of the power system's extensive interconnection. The power systems makes the UHV grid as the core, connects the major coal-fired power bases, water-fired power bases and large-scale renewable energy bases, and combines distributed power and micro-grid.

However, due to the volatility and intermittent nature of renewable power, the access of renewable energy power to the existing grid will cause difficulties in steady-state operation and transient operation. At present, the problems of abandoning wind and abandoning electricity of large-scale photovoltaic power plants and wind power plants need to establish appropriate delivery methods and consumption policies. Distributed renewable energy is a way to effectively use renewable energy and reduce coal consumption. Due to the randomness of distributed user behavior, it is necessary to support information such as information and scheduling for distributed power access to the grid. An interconnected grid requires a grid structure that combines main grid, local grid, and microgrid. Therefore, the new power system is an inevitable trend of energy development. The extensive interconnection of the new power system has promoted the use of clean energy. Therefore, the development of a theorem system extensive interconnection has important research significance. At the same time, on the existing basis, in order to realize the characteristics of the extensive interconnection of the new power system, it is necessary to support them with the corresponding technologies [5].

4. Technical requirements for extensive Interconnect Characteristics of Power System

4.1. *Physical interconnection of the power grid*

(1) Interconnection of transmission channels. It is necessary to continuously improve grid transmission capacity, configuration capability and economy. The main areas include UHV AC and DC transmission technology, flexible DC transmission technology, intelligent substation technology, submarine cable technology, new transmission technology, microgrid technology, distribution network technology and large grid operation control technology. Starting from the interconnection of transmission channels, this paper lists the key technical system in Table 1.

Table 1. The key technical system of transmission channels

Traditional power transmission and transformation technology	UHV AC and DC transmission technology
	Flexible direct current transmission technology
	Intelligent substation technology
	Submarine cable technology

Power distribution technology	Superconducting force technology
	Wireless transmission technology
	Pipeline transmission technology
	Distribution automation technology
	Microgrid technology
Large grid operation control technology	

In recent years, China's UHV transmission technology has developed rapidly. UHV power grids send wind power, solar power and southwestern hydropower in the northwest to the power load centers in the eastern coastal areas [6]. With the development of a power systems, UHV transmission networks are required to further increase transmission capacity and distance. In order to improve the utilization of marine resources such as offshore wind power, high-voltage, long-distance, and large-capacity submarine cables are the main technical directions for future development [7]. At the same time, it promotes the development of new transmission technologies. Microgrid operation control is mainly focused on the research of simple form of AC microgrid. In the future, it needs to be in the complex form of AC/DC hybrid microgrid, cogeneration of microgrid and multi-microgrid parallel control technology. Large-scale power grid operation control technology is an important basic platform for centralized power collection, long-distance intercontinental transmission and large-scale flexible configuration. The future should be developed to the large grid security mechanism, characteristics and analysis technology, power grid fault diagnosis, recovery and automatic reconstruction technology.

(2) Interconnection of multiple forms of energy. The core is the improvement of clean energy development efficiency and economy, focusing on wind power, solar power and distributed power technology. Starting from the interconnection of multiple energy forms, this paper lists the key technical system in Table 2.

Table 2. The key technical system of multiple forms of energy

Centralized new energy generation technology	Wind power technology
	Solar power technology
	Marine power generation technology
Distributed new energy generation technology	Distributed wind technology
	Distributed solar power technology
Energy storage technology	Physical energy storage technology
	Electrochemical energy storage technology
	Electromagnetic energy storage technology
Energy router	

For wind power technology, wind power single-machine capacity large-scale technology, low wind speed technology. At the same time, the development of large-scale wind farms to the deep sea. For solar power generation technology, it is mainly focused on material innovation to improve the photoelectric conversion efficiency. At the same time, the development of solar tracking technology to improve the efficiency of utilization. In the future, distributed power supply technology will focus on distributed power supply grid-connected protection, control, power quality detection technology. Research on energy routers is still at a relatively basic stage. Energy routers are of great significance in the concentration, conversion, and distribution of multiple energy sources. Future research on energy

routers should pay more attention to their practical applications and practices [8]. Large energy storage can be used for peak shaving in a power systems. Large-scale, long-term energy storage facilities such as pumped storage and compressed air storage can be used for peaking of large power grids [9]. Energy storage can be used to store surplus wind and solar energy to power fuel electric vehicles. Large power storage can be used to stabilize the volatility of large-scale clean energy. Supercapacitor are mainly operated in conjunction with large-scale renewable energy, which can quickly respond to the output of wind power and photovoltaic power generation and stabilize fluctuations in renewable energy. To ensure the real-time operation safety of the power grid. Small energy storage batteries can be used in electric vehicles. The key to the advancement of energy storage technology lies in the breakthrough of material technology.

4.2. Grid information interconnection

Information and communication technology is an important basis for realizing intelligent, interactive and large-scale power grid operation control, mainly including information and communication technologies. The extensive interconnection of the new power system requires the rapid growth of information and communication content and the wide expansion of the scope of information and communication. Starting from the grid information interconnection, this paper lists the key technical system in Table 3.

Table 3. The key technical system Information and communication technology

Communication technology	Optical Fiber Communication
	Satellite communication technology
	Mobile Communication Technology
Information Technology	Internet of Things technology
	Ubiquitous internet
	Sensor Technology
	Image recognition technology
	Cloud computing and cloud storage technology
	Big data technology
Information physics system	

The future development direction of information and communication technology is broadband, digital, intelligent, personal and integrated. The information physics system is a multi-dimensional complex system of integrated computing, network and physical environment. It realizes the integrated design of computing, communication and physical systems, which can make the system more reliable, efficient and real-time synergy [10]. Information and communication will provide safer, more reliable and more reliable technical support for the construction and operation of a power system. Information and communication technologies will integrate information communication network construction, image recognition technology, cloud computing and cloud storage technologies and big data technologies [11]. Provide a strong information and communication architecture for the extensive interconnection of power system.

5. Conclusion

The change of power structure is the biggest feature of the new power system. Changes in the power supply structure put new demands on the interconnection of the power system. This paper analyzes the technical requirements of physical interconnection of the power grid and grid information

interconnection. In order to adapt the new power system, the development of related technologies should start from the following three points:

(1) Improve the level of UHV transmission technology. UHV DC transmission is an important way to solve large-scale clean energy long-distance transportation. To meet the power flow under the new power system, it is necessary to further increase the UHV transmission capacity and distance.

(2) Reduce the cost of clean energy generation. The energy density of clean energy is much lower than that of traditional fossil energy. Through technological innovation, the energy conversion efficiency of wind power and solar energy will be improved, and relevant energy storage technologies will be developed to improve the utilization level of clean energy.

(3) Strengthen innovation in grid communication technology. With the rapid development of clean energy and the electricity market, the demand for information interconnection in power systems is increasing. Promote the widespread interconnection of next-generation power systems by new technologies such as artificial intelligence.

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