Study on the Complementary Characteristics of Multi-Power Supply and the Local Absorption Capacity and Outward Demand of New Energy in West China

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Abstract. This paper studies the multi-power complementary characteristics of the western power supply and the local energy consumption and delivery requirements of new energy sources. Based on a comprehensive analysis of the characteristics of western energy power, the paper studies the spatial and temporal differences and adjustment performance of the main power base output characteristics. Based on the complementary characteristics of the western multi-power source, the western power supply capacity and delivery demand of the western power are reasonably evaluated, and the theoretical basis for solving the large-scale new energy consumption in the west is provided, and corresponding suggestions are put forward.

Introduction

At present, there are many studies on the local energy consumption capacity and delivery demand of new energy sources. Literature [1] proposes a scheme to absorb new energy by using a regional thermal system with deep coupling of cogeneration unit and power system. Based on the establishment of accurate static/dynamic thermodynamic analysis model of thermal pipe network, a heat pipe network is proposed. Regional grid electric—thermal joint optimization strategy for energy storage. In [2-3], the paper proposes a distributed optimization scheduling method based on Benders decomposition for the privacy problem of electric and thermal system information belonging to different stakeholders under the hybrid energy system. The literature [4] implements wind power grid-connected elimination. At the same time of optimization, the cost of desulfurization and denitrification equipment operation, SO2 and NOx emission charges were added. The literature [5-6] proposed a variety of peaks based on modular hierarchical structure and fuzzy control adjustment algorithm. Heat pump - mixed energy storage coordinated control strategy with valley filling and wave sway function to improve the energy consumption capacity of electric-combined system renewable energy. In [7], the wind power independent delivery model, the thermal power independent delivery model, the wind power and thermal power combined delivery model are established respectively. Based on the game theory, the profit distribution is improved to improve the peaking intention of the thermal power unit and reduce the waste of wind power resources. The role of the inter-regional carbon trading spread and the sensitivity analysis of the grid power transmission fluctuations, the multi-angle study of the impact of different factors on the profit distribution mechanism of the combined fire and power system.

The above studies have considered the local energy consumption and delivery requirements of new energy at the technical level, but did not consider the complementary characteristics of multiple power sources. Based on the study of the characteristics of economy, energy and electricity consumption in the western region, this paper investigates the power output characteristics of the main energy bases in the western region of China including wind power, solar power, hydropower and thermal power, and studies the spatial and temporal differences and adjustments of the output characteristics of major power bases. Performance, analysis of the complementary characteristics of the western multi-power source based on this, constructing the energy and power comprehensive utilization mode and typical scenarios of the new energy in the west, and analyzing the local in-situ capacity and delivery demand of the new energy in the western region under different scenarios.
Western Power Grid Power Flow Pattern

The energy consumption in the western region is dominated by coal. Since 2000, the electricity consumption in the western region has increased in proportion to the national electricity consumption. The contribution to the national electricity consumption growth is higher than the contribution to the national GDP growth. The electricity consumption in the western provinces is also the first. The secondary industry is the mainstay, and the electricity consumption per unit of output value in most provinces is higher than the national average.

The western region has continued to develop high-energy-consuming industries in recent years, and its power consumption is dominated by the secondary industry. West to the total area of the country's total GDP, GDP gradually increased, per capita GDP exception of Chongqing is still below the national average. The proportion of the secondary industry in the western region is generally higher than the national average. The western region is dominated by heavy industries, and high energy consumption is a relatively advantageous industry in the western region. Since 2000, the electricity consumption in the western region has increased in proportion to the national electricity consumption, and the contribution to the national electricity consumption growth is higher than the contribution to the national GDP growth. The electricity consumption in the western provinces is also dominated by the secondary industry, and the units in most provinces. The output value of electricity consumption is higher than the national average.

Spatio-temporal Differences in the Output of Each Type of Power Supply

Hydropower

Due to the characteristics of monsoon climate in China, the distribution of water resources in China is extremely uneven in time and space. In terms of time distribution, most of the rivers have uneven distribution of runoff, and the flow between the abundance and dry seasons is quite different, which is characterized by more summer and autumn and less winter and spring. Considering the time-complementary characteristics of clean energy such as wind power and hydropower, and rationally planning the power dispatch plan for each quarter, it will help the rational use of clean energy and increase the proportion of clean energy power generation in the whole network. In terms of spatial distribution, the water resources west of the Beijing-Guangzhou Railway account for more than 90% of the country's total resources, including the most in the southwest, accounting for 70% of the country; followed by the central and southern regions, accounting for 10% and 13% respectively; North China, Northeast China and The proportion of East China is small.

Wind Power

In time, the wind resources have different stochastic volatility at different time scales: the minute-level time scale has a large probability of large fluctuation, while the time scale above the hour-level has greater volatility, and the nighttime wind is often greater than the daytime wind; In addition, the wind power output characteristics have obvious seasonal characteristics, and the overall appearance is large in winter and spring, followed by autumn and the smallest in summer.

Photovoltaic

The spatial distribution of solar energy in China is: the solar radiation is generally higher in the western region than in the eastern region, and the northern region is higher than the southern region. In time, solar power generation can only be carried out during the day; and, due to the time difference factor, solar power generation in Xinjiang and solar power generation in central and eastern China have good spatial complementarity in time.

The Regulation of Thermal Power

In general, thermal power is a stable power source, which supports the power generation dispatching of clean energy such as landscape water considering the complementary features of
time and space. It can stabilize the impact of stochastic volatility of new energy power generation on the power grid, and ensure the safe supply of power and the power system.

Analysis of Complementary Characteristics of Multiple Power Sources in the West

Hydropower Output Compensation Photovoltaic Power Generation Output

1) Hydropower primary compensation photovoltaic power supply sawtooth fluctuation

The related research shows that the photovoltaic sunrise process in typical weather shows that on sunny days, the output curve is smooth and the parabola is downward-facing; when it is cloudy, cloudy, shower, light rain, light snow, sand and other weather, the output curve is It is a zigzag with frequent fluctuations and large fluctuations. The hydropower primary compensation photovoltaic power generation is to use the rapid adjustment capability of the hydropower unit to eliminate the zigzag output process of the photovoltaic power generation.

2) Intermittent, volatility and random secondary compensation of hydropower for photovoltaic power generation

The hydropower secondary compensation photovoltaic power generation is based on the primary compensation (based on the smooth photovoltaic output curve). The reservoir can be used to regulate the water storage capacity and the hydropower unit can quickly change the output capacity, further eliminating the intermittent and fluctuation of the photovoltaic output. Sexuality and randomness, so that the output of photovoltaic power generation is kept at a constant value during the day.

Photovoltaic Power Generation Power Compensation for Hydropower

1) Medium and long-term dispatching of photovoltaic power generation to compensate for hydropower

Relatively speaking, due to the small annual fluctuation of solar energy resources, the annual power generation of photovoltaic power generation is stable, which will compensate for the decline of hydropower generation in dry years and form inter-annual complementarity; on the other hand, photovoltaic power generation has winter The seasonal characteristics of large power generation in spring and small power generation in summer and autumn can form seasonal complementarity with the characteristics of small hydropower in winter and spring and large electricity in summer and autumn.

2) Compensation for hydropower by PV power generation in peak shaving operation

During the daytime, when the photovoltaic power station is responsible for the grid load, the hydropower can reduce the output during the corresponding period, or shorten the running time at low load, so that the reservoir reserves more water energy. Until the peak load period of the grid, if the hydropower station can use the additional amount of water stored in the reservoir for peak shaving, it will increase the peaking power of the hydropower station, and the increment is equal to the photovoltaic power generation. Increasing the peaking power will increase the peaking output of the hydropower station and prolong the peak running time, which will help improve the peaking efficiency of hydropower.

Water/Wind/Light Year Complementarity Analysis

The output of hydropower stations is divided into flood seasons and dry seasons according to the incoming water conditions. The annual flood season is from June to October. The amount of water coming is large, and the corresponding power generation is large. From November to May, the water supply is small, and the amount of water is small. The amount of electricity generated is small. Wind power and photovoltaic power generation in the dry season can make up for the shortage of electricity during the flood season. In general, the monthly output of wind power and hydropower showed obvious forms of “one peak and one valley”. The “peak” and “valley” of wind power corresponded to the “valley” and “peak” of hydropower in time. A more unified complementary relationship between wind and water. The difference in photovoltaic power generation is small each month, but it also shows a complementary relationship with hydropower.
Water/Wind/Light in-day Complementarity Analysis

Wind power photovoltaic power generation is affected by environmental factors such as meteorology, so the short-term volatility is very large; especially, photovoltaic power generation is affected by solar radiation, and the intraday fluctuations are large, and only generate electricity during the day, and the night output is zero. The output of wind power is large in the afternoon and midnight, and there is a certain complementarity in the daily output of photovoltaic power plants and wind power. The characteristics of hydropower output are closely related to the amount of water. The amount of water in the rich and dry seasons is large, so the seasonal fluctuations are large, but the daily fluctuations are small; therefore, the output of Water/Light/Wind/Power Station also has good complementarity within the day.

Study on the Local Consumption Capacity of New Energy in the West

The new energy acceptance capacity is affected by factors such as system load characteristics, power supply structure and regulation capability, external call/outgoing power scale and operation mode, and new energy output characteristics. This paper new energy consumptive capacity of the means: in a given system load level on the research level, load characteristics, in addition to the new energy and corresponding to the layout of the power installed technical and economic parameters, new energy output characteristics, constant throughout the year Under the maximum power-limiting ratio (for example, 5%), the system can support the new energy installed capacity by optimizing the operation mode of each type of power and the power flow of the inter-zone delivery channel. Based on the above definitions, the main purpose of studying the new energy consumption capacity is to find the new energy acceptance boundary bound by the grid operation technology, that is, the maximum new energy installation scale that the system can carry under the constraints of a certain power grid structure.

According to the Northwest coal remodeling of electricity flexibility designed two scenarios for the Northwest Territories new energy area in place consumptive ability of forecast results. Visible, 2030 west north area of new energy in place consumptive capacity is 315 MW. After the flexible transformation of thermal power, the capacity of consumption can be increased by 40 million kilowatts.

Table 1. Local energy consumption capacity of new energy in the Northwest region under different scenarios (unit: 10,000 kW).

| Key industry load | Baseline scenario wind power | Photovoltaic | High thermal power flexibility scenario wind power | Photovoltaic |
|-------------------|-----------------------------|--------------|-----------------------------------------------|--------------|
| 100               | 200                         | 150          | 200                                           | 200          |
| 200               | 400                         | 350          | 400                                           | 400          |
| 500               | 1000                        | 1000         | 1000                                          | 1000         |
| 1000              | 2000                        | 2000         | 2000                                          | 2000         |

In-depth digging in key industries load response potential is an important means of improving new energy to the consumptive capacity. The following study of the steel industry and the non-ferrous chemical industry through the peak production to achieve the transfer of electricity, and then participate in the load response benefits. The following table shows the different key sectors to participate in load size load ring seasonal, promotion of new energy-place elimination assimilative capacity.

Table 2. Key energy consumption in the northwest region when the key industry load participates in the load response (unit: 10,000kW).

| Key industry load | Baseline scenario wind power | Photovoltaic | High thermal power flexibility scenario wind power | Photovoltaic |
|-------------------|-----------------------------|--------------|-----------------------------------------------|--------------|
| 100               | 200                         | 150          | 200                                           | 200          |
| 200               | 400                         | 350          | 400                                           | 400          |
| 500               | 1000                        | 1000         | 1000                                          | 1000         |
| 1000              | 2000                        | 2000         | 2000                                          | 2000         |
Study on the Demand for Delivery of New Energy in the West

Binding the above study, consideration provinces new energy output while the output of the new energy and temporal differences in the overall regulation of the effect of new energy output, of West North area of new energy outgoing demand into line calculations, the results shown in the following table.

Table 3. Considering the complementary nature of multi-type power supply 2030 west north area of new energy outgoing demand (unit:MW).

|                  | General scenario | Electrical acceleration scenario |
|------------------|------------------|---------------------------------|
|                  | wind power       | Photovoltaic                    | wind power       | Photovoltaic                    |
| Shanxi           | 707              | 898                             | 800              | 1016                            |
| Gansu            | 1213             | 1283                            | 1371             | 1451                            |
| Ningxia          | 808              | 514                             | 914              | 581                             |
| Qinghai          | 808              | 1411                            | 914              | 1597                            |
| Xinjiang         | 1424             | 2182                            | 1611             | 2467                            |
| Northwest        | 1984             | 5030                            | 2244             | 5690                            |

General situation next scene, northwest of new energy demand sent outside to 70.14 MW; accelerate electrification love scene, the Northwest Territories of new energy sources outside the restaurant needs 79.33 MW.

Table 4. New energy outsourcing demand in the northwest region after 2030 implementation of key industry load response (unit:MW).

| Key industry load | General scenario | Electrical acceleration scenario |
|-------------------|------------------|---------------------------------|
|                   | wind power       | Photovoltaic                    | wind power       | Photovoltaic                    |
| 100               | 2184             | 5180                            | 2444             | 5840                            |
| 200               | 2384             | 5380                            | 2644             | 6040                            |
| 500               | 2984             | 6030                            | 3244             | 6690                            |
| 1000              | 3984             | 7030                            | 4244             | 7690                            |

When the 10 MW focus of the industry to participate in load response program, the routine at the scene northwest of New Energy outgoing need to seek to reach 11014 Wan kilowatts, reached outgoing electrical demand under the scenario of accelerating 11934 Wan kilowatts.

Suggestion

The power grid company should take measures to promote key measures for the new energy consumption in the west. In the western part ferreting out potential regional power peaking side, strengthening the Western part peaking support among the provinces, the reasonable control of the government to coordinate the construction of new energy speed and scale. Coordinating the power supply side to improve the power supply regulation capability to provide more peaking capacity, expand the grid coverage on the grid side, implement demand side response and power substitution on the load side, and develop and improve the market mechanism that is conducive to large-scale optimization of new energy. Further develop the smart distribution network, combine the construction of power and Internet of Things, and do a good job of adapting to distributed new energy and diversified load access. Continue to improve the safe and stable operation level of the receiving power grid, and carry large-scale power transmission from west to east.

Government departments should create a policy environment conducive to the absorption of new energy. Improve the new energy target guidance system. We will improve the green certificate system, promote the construction of a competitive power market, promote inter-provincial cross-regional power trading, realize the optimal allocation of national resources, establish and improve the auxiliary service market, and improve the flexibility of system operation. Implement the “One Belt, One Road” initiative to accelerate the participation of hydropower, wind power and photovoltaic industries in the development of the global clean energy market. Optimize the business environment and reduce the non-technical costs of wind power and solar energy development and
construction. All sectors of society work together to promote new energy consumption and delivery. Establish a unified scientific planning and operation management system for all walks of life, and promote the coordinated development of the source network. Adhere to unified planning, unified scheduling, unified management, and ensure the safety, economy, quality and efficient operation of the power system, and enhance the intensity of new energy consumption. Vigorously develop high-precision electric power meteorological forecasting technology, new energy unit frequency modulation and voltage regulation technology, and promote new energy-friendly grid connection. Develop advanced grid-connected technologies to meet the needs of new energy-using facilities such as distributed energy. Establish an effective price incentive mechanism for thermal power to participate in peak shaving, cross-provincial cross-regional joint peak shaving, break the inter-provincial barriers, and improve the optimization of allocation efficiency and economic competitive advantages of clean energy resources.

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