Analysis on the change of power structure and new energy absorption capacity of Shandong power grid

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Abstract. According to the current situation and future development trend of power structure of Shandong power grid, this paper analyzes the problems brought by the large-scale access of new energy and the effective measures taken by Shandong power grid under the new situation, and puts the supporting measures of fully absorbing new energy power generation into practice.

1. Introduction

In recent years, the rapid growth of the Shandong power grid as an electric in Shandong, the rapid rise of the new energy power generation, Shandong power grid by relatively independent operation and power balance itself to the ac/dc hybrid power grid transformation [1], for the province's economic development and people's living growing electricity demand provides a strong protection, withstood the new peaks in the summer of 2018 the province's electricity load a severe test.

However, wind power, solar power and other new energy power is an important feature of different from traditional power generation is the stochastic volatility, the large scale power grid will be made after originally relatively controllable power supply power system of traditional lateral controllability is greatly reduced, in the case of electric access ratio increasing, safe and economic operation of Shandong power grid will have far-reaching influence, also the operation mode of the coal-fired units put forward higher requirements.

2. Shandong power grid continues to enrich the power structure

Shandong power grid is an independent power grid composed of a pure thermal power system, which has been gradually developed into an uhv ac-dc hybrid power grid.

2.1. Shandong power grid installed capacity is increasing

At the end of 2011, the total installed power capacity in the province was 68.128 million kW, among which thermal power was 64.557 million kW, accounting for 94.7%. Wind power and photovoltaic power generation 2.502 million kW, accounting for 3.7%; Hydropower and pumped storage capacity is 1.069 million kW, accounting for 1.6% [1].

By the end of June 2018, the installed capacity of the whole network was 99.802 million kW, and that of thermal power was 76.395 million kW, accounting for 76.55%. Pumped storage unit capacity 1
million kW, accounting for 1.00%; Wind farm installed capacity is 10.811 million kW, accounting for 10.83%; Photovoltaic installed capacity is 11,596,000 kW, accounting for 11.62% [3].

At present, two 1250MW nuclear power units have been put into operation. In 2019, Shandong power grid is expected to put into operation 8.502kw new units, and the installed capacity of the whole network will exceed 110 million kW [4].

2.2. Continued progress was made in the project to bring electricity into Shandong province from abroad

Before that, Shandong power grid was basically a pure thermal power system. In 2005, Shandong power grid was connected to north China by 500kV, and Shandong power grid began to transform from relatively independent operation and power self-balance to ac-dc hybrid power grid.

At the end of 2011, Shandong power grid connected to two points in north China through 500kV Huangbin double line and Xin-dang double line, and achieved bipolar operation at ±660kV Yandong dc point in Qingdao Jiaozhou. Shandong received external power up to 7500MW, which became an important support to ensure orderly power supply of the province [1]. In 2017, Shandong's uhv ac-dc hybrid power grid was initially formed, and the capacity of Shandong to receive electricity from outside the province reached 15 million kW, providing a strong guarantee for the province's economic and social development and air pollution prevention and control. At present, Shandong is increasing the "external power to Shandong" to boost the energy transformation. By 2019, it will build and put into operation the 1000kv Shandong-Hebei ultra-high voltage ring network project, and by 2020, Shandong will receive more than 30 million kW of external power [5].

2.3. New energy generation is growing rapidly

New energy generally refers to the renewable energy that is developed and utilized on the basis of new technologies, including solar energy, biomass energy, wind energy, geothermal energy, wave energy, ocean current energy and tidal energy. The widely used coal, oil, natural gas, water energy, nuclear fission energy and other energy, known as conventional energy. New energy power generation is the use of existing technology, through the new energy, the process of power generation.

In the world, wind power and photovoltaic power generation rise suddenly, and presents a large-scale and concentrated development trend; In China, the growth rate of new energy power is also very rapid. Since 2010, the wind power installed capacity has been the first place in the world, surpassing the United States for the first time. Photovoltaic power generation is growing at the rate of nearly doubling year by year, and the newly installed photovoltaic capacity climbed to the first place in the world in 2013 [2].

Shandong province's new energy generation is also very rapid. In 2011, the installed capacity of wind power and photovoltaic power generation was 2.502 million kW, accounting for 3.7%. By the end of June 2018, the installed capacity of wind power and photovoltaic power was 22.407 million kW, accounting for 22.45%. By the end of 2018, the installed capacity will reach 24 million kW. In 2019, the installed capacity of wind power and photovoltaic will reach 27.9 million kW, and the installed capacity of new energy will account for nearly 25 percent. According to the plan, the clean energy installed capacity in Shandong province will reach more than 31 million kW in 2020 [5].

2.4. Shandong power grid power load continues to increase

On July 16, 18 and 20, 2018, the power load of Shandong power grid reached a new high, reaching a maximum of 770.08 kW. At 13:45 on July 25, the power load of Shandong power grid reached a new high again, reaching 80.222kW, 11.1% higher than last summer's peak, and breaking the 80,000,000 kW mark for the first time. Since then, the whole network load reached a new high, the highest load reached 81.653 million kW. It is predicted that the maximum power load of Shandong power grid will reach 90 million kW in 2019, 10.2 percent more than this year's peak.

Shandong power grid has enriched the power structure of the grid and improved the power supply capacity by introducing external power, vigorously developing new energy power generation, and establishing pumped storage power station and nuclear power station. However, compared with the
rapidly increasing power load, Shandong power grid still has a certain gap, so it needs to continue to increase the power grid capacity to meet the electricity demand of the whole province.

3. Shandong power grid takes multiple measures
At present, Shandong power grid expanding capacity, voltage level enhances unceasingly, grid electric's ability to accept the continued ascension (on July 25, 2018 provincial actual calls up to 14.5 million kW, a record high [3]), more and more single capacity of more than 1 million kW thermal power unit parallel operation of wind power and photovoltaic power generation and installed capacity of more and more (on November 10, 2017, new energy maximum output is 10.659 million kW, accounted for 21.19% of the straight adjust biggest electricity load), nuclear power units move smoothly into production. All these provide a strong guarantee for the province's economic and social development and the increasing demand for electricity and air pollution prevention and control

Previously, Shandong power grid mainly relied on thermal power unit peak regulation, pumped storage capacity as a supplement, under normal circumstances can basically meet the operational needs. As the grid capacity and the increasing of the power load, the power structure and the diversity of access, the continued expansion of new energy power in proportion to the power grid, power system had to between the random fluctuations of power supply side and load side to achieve the balance of supply and demand in energy, traditional power system in the randomness, controllability, safety, integrity and intelligent characteristics change will increasingly significant [2], the equipment, operation control, and power supply side of the grid in such aspects as the response of the new requirements are put forward

3.1. The problem of new energy consumption in Shandong power grid

3.1.1. Wind power and photovoltaic power generation have great influence on the stability and power quality of power grid. New energy generation, such as wind power and solar energy, has the characteristics of intermittence, volatility and randomness. Large-scale access to the power grid will have a great impact on the stability and power quality of the grid. The instability and intermittently of wind speed also have a great impact on the power generation. After the grid connection, it will have the characteristics of reverse regulation, so it is necessary to reserve more power in the grid and increase the difficulty of wind power dispatching. The power of the photovoltaic power generation system is also intermittent and unstable, and the photovoltaic power generation system does not have the function of peak regulation and frequency modulation, which requires the addition of more rotary standby units to ensure the normal supply of electricity during the peak period

3.1.2. Shandong power grid over-relies on coal-fired power units for power side dispatching. Can quickly response to the requirements of the grid is gas and hydroelectric units, but there is no gas generator set in Shandong province, you can schedule of hydroelectric units only 4 units of 250000 kW of pumped storage units, provincial electricity and basic no nuclear power adjustment ability, new energy power generation is not good for power grid scheduling, to a certain extent, therefore, scheduling means of Shandong power grid in power supply side still rely on coal-fired units, it is both opportunity and challenge for coal-fired units, in order to adapt to the requirements of power grid rapid response, the depth of peak shaving, must transform

3.1.3. Shandong power grid still has power supply gap during peak period. Although the total installed capacity of Shandong has reached 100 million kW, there is still a shortage of electricity at the peak time. At 14 o’clock on July 31, Shandong power grid launched the orderly power consumption measures for the first time this summer to ensure the balance between supply and demand of Shandong power grid and give priority to people's livelihood. The maximum orderly power load is 6.612 million kW. It is predicted that the maximum power load of Shandong power grid will reach 90 million kW in 2019, 10.2 percent more than this year's peak. Considering the two units of haiyang nuclear power, zhao interpretation of dc production and sustained growth of new energy, during the summer of 2019 Shandong power grid power supply ability is currently about 7 million kW, according to the entire
network of up to 90 million kW load level prediction, peak period will be about 3 million kW power
gap [4], contradiction between supply and demand will continue to exist in a long time

3.1.4. The state has been issuing policies to improve the power grid absorption capacity of new energy.
Due to the negative impact of wind power and photovoltaic power generation on the grid, the grid
absorption capacity is insufficient, and the problem of abandoning wind and electricity in rich areas of
wind and solar energy is becoming more and more serious. For this reason, the electricity regulatory
commission issued "two detailed rules" as early as in 2009 to evaluate the variable load operation
capacity of grid-connected units. Obviously, although the original intention of the formulation of the
"two detailed rules" does not focus on the large-scale access of new energy power, it does facilitate the
grid connection of new energy power in China.

On November 7, 2016, the national development and reform commission, the national energy
administration issued the electric power development "much starker choices-and graver consequences-in planning (2016-2020)" file, one of the key tasks: (7) to strengthen the construction of load capacity and
improve the system flexibility, attaches great importance to the power system to adjust capacity
building, from the load side, power supply side and grid side measures simultaneously, fully tap the
existing system load capacity, increase the intensity of peaking power source planning and construction, strive to enhance the system flexibility and adaptability of the new energy given problem.

3.2. Measures taken by Shandong power grid to improve the absorption capacity of new energy

3.2.1. Build a pumped storage power station. Pumped storage units for Shandong power grid peak
shaving and valley filling, frequency modulation, phase modulation, load standby and emergency task, only Taishan pumped storage power station of the currently running four sets of 250000 kW unit, river bank Mongolia pumped storage power station (installed capacity of 1.2 million kW), Shandong Whedon pumped storage power plant (power station installed capacity of 1.8 million kW) is under construction, is expected to begin in 2021. Weifang pumped storage power station (installed capacity of 1.2 million kW) project has entered the substantive implementation stage, strive to approve the start of construction by the end of 2018. The construction of these storage power stations can effectively solve the problem of serious shortage of peak load regulation capacity of the power grid, optimize the power structure of the grid, improve the power supply quality of the grid, improve the economy, safety and stability of the grid operation, and strongly support the implementation of the strategy of "external power to Shandong", so as to better consume and absorb trans-regional clean energy.

3.2.2. Continuously improve the peak regulation capacity of thermal power units. Under the premise of
in order to ensure the security of the power supply, inside the limits of power ability, give full play to
the supporting ability of power grid security, Shandong province by the letter committee, electric power
dispatching center department issued for AGC for thermal power unit, a frequency modulation in a
number of requirements and evaluation methods and the construction, expansion and the capacity of the expansion unit shall, in heating season charged load capacity of heating unit for supervision, and examination and after overhaul of the unit to carry out the machine coordinate network test, encourage the implementation of thermal power unit load of depth and flexibility renovation coal unit load ability promotion project, etc.

Flexibility transformation of thermal power units is the general trend, which is conducive to thermal
power to adapt to the process of electricity marketization. Through a series of technical transformation,
the flexibility of peak regulation of units is improved, and the coal consumption of power supply of enterprises is reduced to meet the requirements of national documents (the average coal consumption of power supply is less than 310 g/kW.h). In order to achieve flexibility, the following technical requirements must be met:

(1) Depth peak adjustment: load rate reaches 20% ~ 40%.
(2) Fast climbing ability: 2% ~ 5% MW/min climbing ability.
(3) Quick start and stop: 2 ~ 4h fast start and stop.
(4) Boiler efficiency is not sacrificed under the same operating condition.

On March 23, 2018, the national development and reform commission and the national energy administration issued the guidance on improving the regulation capacity of the power system. Cogeneration unit: minimum technical output reaches 40% ~ 50% rated capacity; The minimum technical output of some advanced power plant units can reach 20% ~ 30% under pure coagulation condition without oil input and stable combustion.

3.2.3. Condenser is in operation. On October 12, 2018, linyi converter station #1 condenser was successfully connected to Shandong power grid, which was the first "three-unit condenser adjustment project" in China, and the first step for Shandong power grid and even north China power grid to the era of reactive power compensation for condenser adjustment. The condenser can quickly provide large capacity transient reactive power support, greatly reduce voltage fluctuations, and maintain the stability of Shandong power grid with the fastest speed, highest efficiency and maximum energy. To some extent, this relieves the operation pressure of coal-burning units.

3.2.4. Actively carry out research on relevant subjects. On November 10, 2018, the province organization held a "kinetic energy conversion between the old and the new environment based on new energy given for safe operation of the power grid and control research" topic on, showing the phased achievements fully affirmed, puts forward the requirements of the next step work, especially in the new energy electric power prediction, large-capacity energy storage technology and grid strategy as the key research direction.

4. Conclusion

Shandong power grid has implemented supporting measures to fully absorb new energy power generation. In the case of new energy power generation reaching a new high, there is no problem of abandoning phoenix and power, and the state policy is implemented in place, leading the grid. However, as a large and complex system, Shandong power grid has no revolutionary breakthrough in external power supply, large-scale new energy generation and energy storage technology. Firstly, it is necessary to improve the research on key technologies of new energy supply, such as wind power and photovoltaic power generation, to reduce the impact on power grid stability and power quality. Secondly, the grid itself must speed up the construction and investment of pumped-storage power station, modulator and other rapid response equipment and systems, so as to improve the grid's self-adjustment capacity. At the same time, coal-fired power units must become the dominant complementary power source and constantly improve their flexibility and depth peak regulation ability to meet the demand of power grid peak regulation.

Shandong power grid must build a development model based on power supply response, power grid response and demand side response, so as to ensure safe and efficient operation of new energy power while maximizing access.

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