Regional grid energy storage adapted to the large-scale development of new energy development planning research

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Abstract. After the carbon neutral target is proposed, China's new energy will usher in a leapfrog development, and its volatility and randomness put forward higher requirements for the flexibility of the power system. Energy storage has strong flexible adjustment capabilities. With the continuous improvement of technology and economy in recent years, it has been promoted and applied in all aspects of the power system, and its value in improving system flexibility is gradually reflected. This paper satisfy the power balance system and new energy given perspective, aiming at the lowest cost of power supply, regional energy storage size optimization model is put forward, with a actual regional power grid as an example, has carried out empirical research, quantitative analysis of correlation between the development of new energy and energy storage scale and verify the model is scientific and accurate.

1 Introduction

General Secretary Xi Jinping made a solemn promise to the international community on "carbon peak and carbon neutrality" at the 75th UN General Assembly, and put forward specific goals at the Climate Ambition Summit. Energy storage is a key technology to support the large-scale development of new energy and green emission reduction, but the coordinated development method and path of energy storage and new energy are still unclear[1-3]. How to rationally plan the scale of energy storage development in the regional power grid is a key issue that needs to be resolved. In the medium and long term, the key to successfully achieving the goal of “carbon neutrality”is to solve the problem of optimizing the allocation of flexible adjustment resources such as energy storage and coordinating development with the overall optimization of the power system under the situation that the proportion of new energy is gradually increasing[4-6]. This article focuses on a province Level grid, using the power planning software GESP to carry out research on the optimization of the scale and layout of energy storage development, and propose an energy storage optimization planning method that adapts to the large-scale development of new energy.

2 Research content, scenario settings and research tools

2.1. Research content and ideas

Under the dual-carbon goal, new energy in Jiangsu Province is expected to usher in leapfrog development during the 14th Five-Year Plan period. In view of the problem that the coordinated development mode and path of energy storage and new energy are still unclear, this study intends to solve the following two problems:

(1) Optimize the development scale of energy storage in Jiangsu Province during the 14th Five-Year Plan. Under the goal of carbon peak and carbon neutrality, new energy in Jiangsu Province is expected to grow rapidly during the 14th Five-Year Plan period, with installed capacity reaching 64 million kilowatts, including 28 million kilowatts of wind power and 36 million kilowatts of solar power. In order to meet the demand for power supply and new energy consumption, aiming at the lowest total power supply cost, comprehensively considering the constraints of non-fossil energy development, power balance, peak shaving balance, and new energy consumption, and considering coal power, gas power, and electricity storage According to the technical and economic differences of various types of technologies, the optimal energy storage development scale of Jiangsu Power Grid during the 14th Five-Year Plan period was obtained through power planning model optimization.

(2) The cooperative development relationship between energy storage and new energy during the 14th Five-Year Plan. Study the optimal energy storage configuration scale under different new energy development scales, and analyze the coordinated development relationship between energy storage and new energy.

2.2. Scene setting

In view of the above research content, the following research scenarios are set up:

(1) Baseline scenario-Electric energy storage is not considered in power planning

In 2025, the planned development scale of wind power and solar power will reach 28 million and 36 million kilowatts. The development scale of hydropower, nuclear power, and pumped storage will be given in accordance with the approved status of construction. Consider planning for new power flow and optimize the addition of coal power and gas power. Installed demand.

(2) Optimized scenario-consider electric energy storage in power planning

On the basis of the baseline scenario, the electric energy storage is included in the power plan, and the wind and solar development scale of 28 million and 36 million kilowatts in 2025 will optimize the newly installed demand for coal power, gas power, and electric energy storage.

(3) Sensitivity scenario of new energy installed capacity

On the basis of the optimized scenario, considering the further growth of new energy installed capacity, optimize and analyze the development needs of electricity storage under different installed capacity.

2.3. Research methods and tools

The optimization analysis tool uses the power planning software GESP,GESP（Generation of Electric System Planning）The optimization analysis tool uses the power planning software GESP, which is a multi-regional power supply and power flow optimization software system developed by the State Grid Energy Research Institute Co., Ltd. The main function of GESP software is to provide planners with an optimal plan for power system power supply and power flow expansion and detailed power system technical and economic information related to it, so as to provide a reliable basis for the development of the power system and the entire national economy. GESP has been used many times in national and regional power development planning and power project demonstrations, such as the "Twelfth Five-Year", "13th Five-Year", "14th Five-Year" National Grid Corporation of regional and provincial power grid development plans, and the power supply of the Three Gorges Project Optimization demonstration, economic evaluation of World Bank loan projects, etc. GESP uses the mixed integer programming method to optimize the modeling of power planning problems.

3 Boundary conditions

3.1. Electricity demand

During the "14th Five-Year Plan" period, considering the solid advancement of the strategic adjustment of the regional economic structure, the rapid shift from export-oriented to domestic demand-driven, the development of modern service industries and strategic emerging industries has accelerated, energy efficiency and cleanliness levels have significantly improved, and the demand for electricity Maintain steady growth[7-9]. It is estimated that in 2025, the electricity consumption and maximum load of the whole society will be 820 billion kwh and 150 million kwh respectively, and the average annual growth rate during the "14th Five-Year Plan" will be 5.3% and 5.5% respectively.

3.2. Power flow arrangement

Determine the power transmission scale of the power transmission channel according to the supporting power supply, the construction of the transmitting and receiving end grid, and the load characteristics of the transmitting and receiving end. The newly added transmission channels during the "14th Five-Year Plan" mainly take into consideration the transmission projects clearly promoted by the country during the "14th Five-Year Plan". The newly added DC 8 million kilowatts will increase the capacity of the existing channels by 5.7 million kilowatts. In 2025, the incoming power flow will reach 45.44 million kilowatts.

3.3. Power installed

3.3.1 Non-fossil energy power generation

Conventional hydropower. As of the end of 2020, conventional hydropower installed capacity is 50,000 kilowatts. During the "14th Five-Year Plan", there is no plan to increase conventional hydropower, and the installed capacity remains unchanged. Pumped storage. As of the end of 2020, 2.6 million kilowatts of installed capacity will be pumped and stored. The "14th Five-Year Plan" is expected to add 1.13 million kilowatts of installed capacity. It is estimated that by 2025, the installed capacity of pumped storage will reach 3.73 million kilowatts. nuclear power. The installed nuclear power capacity will reach 5.5 million kilowatts in 2020. During the "14th Five-Year Plan" period, the main consideration is to approve projects under construction, and it is estimated that 1.13 million kilowatts of new installed capacity will be added. By 2025, the installed nuclear power capacity will reach 6.62 million kilowatts. New energy power generation. During the "14th Five-Year Plan" period, the construction of distributed power and offshore wind power will be promoted in accordance with local conditions. It is estimated that the installed capacity of wind power and solar power will be 12.04 million and 4.3 million kilowatts during the 14th Five-Year Plan. By 2025, the installed capacity of wind power and solar power will reach 28 million and 36 million kilowatts.

3.3.2 Fossil energy power generation

As of the end of 2020, the installed capacity of coal power and gas power reached 7,951 and 20.94 million kilowatts, respectively. The scale of coal power and gas power under construction without approval, the newly added installed capacity of the "14th Five-Year Plan" was obtained from the optimization of the model.

3.4. Changes in the cost of various power generation technologies and energy storage technologies

New energy power generation: According to the recent actual construction cost of new energy power plants in various regions and the future downward trend, considering the wind power investment cost of 7,500 yuan/kW in 2020, the average annual rate of 2.5% decline during the "14th Five-Year Plan" period; photovoltaic power generation investment cost in 2020 4180 yuan/kw, an average annual decrease of 5% during the "14th Five-Year Plan" period.

Electrochemical energy storage: The current investment cost is 2,100 yuan/kWh, and it will decrease by 4% annually during the "14th Five-Year Plan" period. There are four types of energy storage models set for 1 hour, 2 hours, 4 hours, and 6 hours for optimization options.

Coal power: The current investment cost is 4189 yuan/kW and remains unchanged.

Conventional gas power: The current investment cost is 5000 yuan/kW and remains unchanged.

4 Optimized results of energy storage development

Under the baseline scenario, the "14th Five-Year" power plan does not consider new energy storage, and coal-fired power and gas-fired power installed capacity increase by 4.15 million and 5.5 million kilowatts. Considering that the installed capacity of wind power and photovoltaic power will reach 28 million and 36 million kilowatts respectively in 2025, the plans for the commissioning of hydropower, nuclear power, and pumped storage are basically clear. The "14th Five-Year Plan" mainly relies on newly added coal power and gas power to meet the power balance and flexibility. Regulate demand, add 4.15 million kilowatts of coal-fired power installed capacity and 5.5 million kilowatts of gas-fired power installed capacity from 2020 to 2025. The total installed power supply capacity will reach 182 million kilowatts in 2025. The discounted value of the total cost of power supply in the planned cycle for 2020-2025 is 573 billion yuan. The utilization rate of new energy is 95.03%, and the carbon emission of electricity in 2025 is 376 million tons.

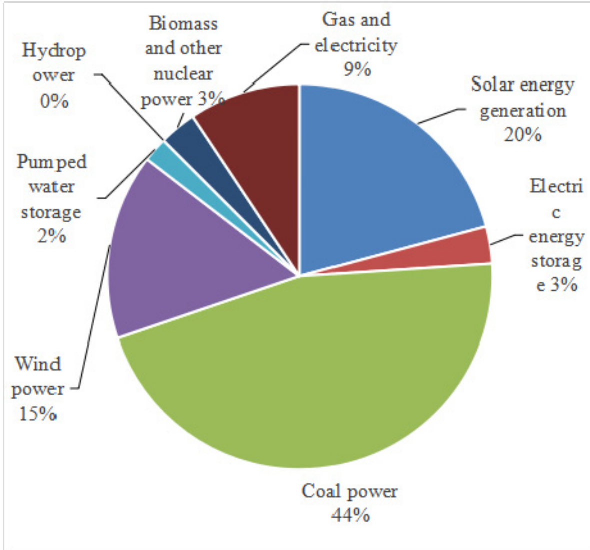

Fig. 1. Power supply installation structure in 2025 under the baseline scenario

From the perspective of energy storage configuration capacity, due to the high utilization rate of new energy, energy storage is mainly used to meet the power balance demand, and the newly installed capacity is mainly one hour of energy storage.

From the perspective of energy storage layout, the new energy storage under the optimized scenario is mainly deployed in northern Jiangsu, reaching 5.5 million kilowatts, accounting for 96%. The main reason is that the load growth in northern Jiangsu is fast and the new energy is mainly deployed in northern Jiangsu.

Table 1. Comparison of results between baseline scenario and optimized scenario

	Newly installed capacity (10,000 kilowatts)				"14th Five-Year" power supply cost (100 million yuan)	New energy utilization rate in 2025	Carbon emissions in 2025 (Ten thousand tons)
	Installed energy storage capacity (10,000 kilowatts)	Energy storage capacity (10,000 kWh)	Coal power	Gas and electricity			
Baseline scenario	0	0	415	550	5730	95.4%	37601
Optimization scenario	570	570	385	0	5607	95.7%	37570

5 Research on the relationship between energy storage and new energy development

On the basis of the optimized scenario, considering the further increase in the installed scale of new energy during the 14th Five-Year Plan period, the optimal energy storage allocation scale under 95% new energy utilization rate was studied, and the reasonable allocation relationship between energy storage and new energy during the 14th Five-Year Plan period was proposed.

Assuming that in 2025, the scale of new energy will increase by 2 million, 4 million, 6 million, 8 million and 10 million kilowatts on the basis of the plan. The relationship between the corresponding new energy storage scale and the new energy installed scale is shown in the table and figure below.

Table 2. Comparison of results between baseline scenario and optimized scenario

Scene number	1	2	3	4	5	6
New energy installed capacity (Ten thousand kilowatts)	3873	4073	4273	4473	4673	4873
New energy storage installed capacity (Ten thousand kilowatts)	570	593	678	748	832	841
New energy storage capacity (Ten thousand kilowatt hours)	570	593	678	818	950	1080
New coal power (Ten thousand kilowatts)	398	356	257	173	73	50
New energy storage capacity/new energy installed capacity	14.6%	14.6%	15.9%	18.3%	20.3%	22.2%

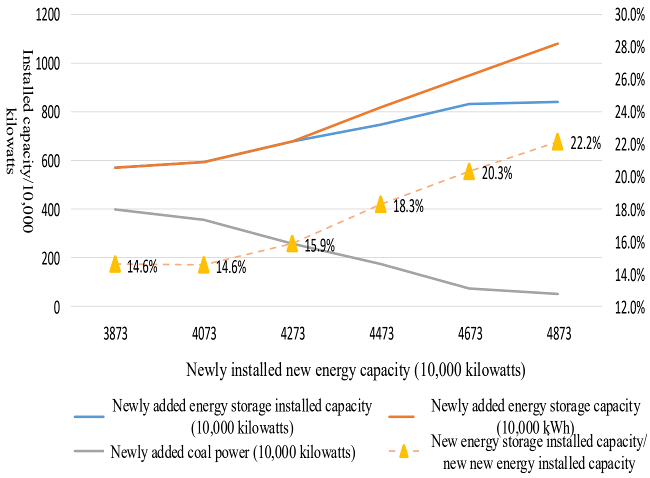

Fig. 2. New energy storage conditions under different new energy installation scales

As can be seen from the above figure, as the scale of new energy installations grows, the demand for coal-fired power installations continues to decline. In order to maintain 95% utilization, the scale of energy storage installations required continues to grow, and the marginal growth rate continues to accelerate. After the newly installed capacity of new energy exceeds 43 million kilowatts, in addition to the one-hour energy storage, two-hour energy storage will be added. Overall, the proportion of new energy storage capacity and new energy installed capacity will be around 15%-20%.

6 Conclusion

This article takes the lowest total power supply cost as the goal, comprehensively considers the constraints of non-fossil energy development, power balance, peak shaving balance, and new energy consumption, and considers the technical and economic differences of various types of technologies such as coal power, gas power, and electric energy storage. Through the optimization of the power planning model, the optimal energy storage development scale of a certain region in the eastern part of the "14th Five-Year Plan" is obtained, and the optimal energy storage configuration scale under different new energy development scales is further analyzed, and the coordinated development relationship between energy storage and new energy is analyzed.

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