Application and Development of New Energy Power Generation in Electric Power Construction

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Abstract: At present, China's electric power construction is confronted with the dual tasks of traditional energy constraints and low-carbon transformation. On one hand, for a long time, China has relied on coal-fired power generation and other fossil fuel-based power generation methods. Although the proportion of coal-fired power generation dropped below 55% in 2024, the non-renewability of coal resources, along with the carbon emissions and air pollution issues during the mining and combustion processes, remain prominent. Additionally, China's dependence on imported crude oil and natural gas exceeds 70% and 40% respectively, posing external risks to energy security. On the other hand, the "dual carbon" goals have set clear low-carbon requirements for electric power construction. New energy power generation methods such as wind power, photovoltaic (PV) power, and energy storage rely on domestic renewable resources and offer the advantages of zero carbon emissions and self-sufficiency. Based on this, this article systematically reviews the core role of new energy power generation in electric power construction, predicts future development trends, and proposes targeted countermeasures from both policy and technological perspectives, aiming to provide references for promoting the deep integration of new energy power generation and electric power construction and achieving a clean transformation of the power system.

1. Introduction

Energy is the foundation of a country economic growth. Electric power construction is not only the foundation of the energy system, it directly affects energy security, environmental quality and sustainable economic growth. Long-term to a large extent of the electric power construction in China is based on coal-fired power generation. While this has helped push economic growth at a rapid pace, it also bears three-fold pressures: low fossil fuel availability, high carbon emission intensity and high foreign energy dependency. It is against this background that the "dual carbon" goals have been proposed, illuminating the direction of electric power construction. As a new power generation method, new energy based on local renewable energy resources like wind and solar energy has the characteristics of zero carbon emissions and distributed supply, which effectively alleviates the shortcomings of traditional electric power construction.

2. The Core Role of New Energy Power Generation in Electric Power Construction

2.1 Promoting Energy Structure Transformation

Given the structural and operational challenges in China's electric power construction process, renewable energy power generation has emerged as a mainstay in promoting zero-carbon or low-carbon energy project and technology application. China has built its power structure based on fossil fuel-based methods of generation for decades now, especially coal. This structure not only encounters numerous issues such as the finite characteristic of coal assets and excessive carbon emission depth from production and use, but additionally contributes to a lots dependence of the electricity device on classic fossil fuels, which is inconducive to the sustainable provision levels. But when constantly expanding the application scale in power construction, renewable energy

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power generation, on the one hand, has been continuously increasing and this clean electricity total supply. By 2024, accumulated installed wind power, PV power and other new energy power generation methods capacity has increased to more than 1.3 billion kilowatts [1], accounting for the country's total installed power generation capacity of more than 45%, still maintaining a rate of growth of over 100 million kilowatts per year, filling up the gap in electricity demand caused by traditional fossil-fuel based power generation In contrast, the low-carbon energy mix has also been increasingly replacing the share of fossil fuel-based power generation. However, the rapid expansion of renewables has seriously restricted the coal-fired power and other fossil fuel-based power generation from increasing their share in the power-filled space while facing steady demand for growing consumption. The share of coal-fired generation in China is now below 55% in 2024, down more than 15 percentage points from levels in the year 2015, directly reducing the power system's reliance on fossil fuels.

2.2 Ensuring Energy Security

There should be preparation for the future, and new energy power generation will play an irreplaceable role in China's energy security, which is mainly expressed in decreasing China's dependence on external fossil fuels, realizing diversification of energy supply capacity, and making up regional gaps of electric power supply level. First of all, as for the reduction of external energy dependence: China's traditional power production has always relied on fossil fuels such as coal and oil. The crude oil dependents have been above 70% for a long time, and the natural gas dependence has also been more than 40%. Thus, international energy prices or supply chain disturbance will easily influence the stable power from [2]. And yet, while traditional energy power generation depends upon resources wind, solar and biomass energy, which are all locally distributed and renewable. In addition, abundant wind energy resources in northwest and north China Regions and abundant solar energy resources in northwest and southwest Regions are also available. New energy power generation will gradually reduce the dependence of the power system on imported fossil fuels by creating these local resources, and then relieve the impact of international energy market fluctuations on domestic power security. Secondly, enhancement of the energy supply system: Traditional power generation relies heavily on coal fired power generation. Local power outages may arise from issues such as a fall in coal production capacity or transportation bottlenecks. But new energy power generation includes many types such as wind, PV, biomass and pumped hydro power. The peak power generation periods of various new energy sources can make up for each other. That is, PV power generation exhibits good day-time performance while wind power generation has night-time stable output. Distributed PV power generation can directly generate electricity on the rooftops in urban and rural areas, and form a "centralized + distributed" multi-supply model, avoiding power security risks caused by insufficient supply of a single energy source. Finally, regarding regional power supply guarantee, in the eastern load centers (e.g., Yangtze River Delta and Pearl River Delta), local power demand is rapidly increasing while shallow fossil fuel resources are very limited, electrical energy must be imported from other areas [3]. However, areas in the west and north where it is difficult to build a power grid will often be affected by unstable supply because traditional transmission is not cost effective. The east can develop distributed PV power generation while large-scale wind and solar power bases can be built in the west, together with dedicated high-voltage channels for transmission. It can not only complement the power for East load centers but also replace diesel power generation in remote areas with "new energy + energy storage" microgrid. This can eliminate local power shortages, as well as regional power security risks caused by cross-regional power transmission failures or insufficient coverage of traditional power supply.

3. Development Trends of New Energy Power Generation in Electric Power Construction

As far as technical upgrades are concerned, the efficiency and performance of new energy power generation are also improving. The share of new energy power generation capacity in China's total will be more than 45% by 2025. Wind and PV power generation has carried out several generations

of technology iterations as the main types; The conversion efficiency of PV silicon cells is increasing year by year, the series connection mode formed by faction modules has been gradually applied from low-efficiency electric fields to high-efficiency modules (maximum power point). These large wind turbines have improved the maximum capacity of a single unit of power generation, reduced the cost of generating one kilowatt-hour and further improved the utilization efficiency of wind energy [4]. Advancements in the energy storage technologies provide a vital support towards this. Projects have been implemented with long-duration energy storage technologies such as compressed air energy storage and flow batteries. For example, in the wind-PV-hydrogen integrated energy storage project undertaken by Yanqing County, the compressed air energy storage system can not only stabilize power output but also supply heating service through waste heat utilization to realize multi-energy coordination. Factor in the fact that smart technologies are deeply embedded. The world's first annual all new energy generation forecasting system in the comprehensive energy sector have been put into use. The high-precision power generation forecasting is realized by combining multiple models including meteorological factor prediction, wind farm and solar power station identification and power generation capacity calculation, which provides scientific support for the planning and operation of power system.

In terms of grid cooperation, promoting the flexible DC transmission technology has become a key direction for development. It can independently control active and reactive power, which has a significant advantage in new energy grid connection and grid connection. Flexible DC technology has solved the grid problem, and we can educate you about the Tancha DC grid project that integrates large scale wind power generation The offshore wind power grid connection project can send 2.4 billion kilowatt hours of wind power annually [5]. Nationwide, large-scale PV and wind power bases in areas including Inner Mongolia and Gansu will primarily use flexible DC technology for transmitting electricity during the 14th and 15th Five-Year Plan periods, while offshore wind power in locations such as Shandong and Fujian will be grid-connected via flexible DC technology. More is set to follow, with 1,400 megawatts of offshore wind power expected to take up the technology over the next decade and considerably increasing," grid flexibility, he added.

4. Countermeasures and Suggestions for Promoting High-Quality Development of New Energy Power Generation in Electric Power Construction

4.1 Policy Level

First of all, the government should take the lead to coordinate and plan to break through the planning obstacles that hinder the implementation of new energy projects. The National Energy Administration should work with relevant departments such as the Ministry of Natural Resources and the Ministry of Ecology and Environment to formulate a unified national new energy development plan, clarify the layout principles of large-scale wind and solar power bases and distributed PV power station, ensure accurate alignment between new energy plans, national land spatial planning and ecological protection red line planning. For instance, it is necessary to demarcate special new energy construction areas in the "sand dunes and deserts" regions of northwest China in order to avoid occupying farmland, grasslands and nature reserves [6]. Local governments should improve local implementation plans in line with the national plan, implement a green channels for land use approval of new energy projects, shorten the decision time for unused land demolition zones such as desert and Gobi desert, reduce project initiation time from planning to beginning; we will not allow local authorities arbitrarily stop approved compliant new energy projects through ecology protection reasons in order to maintain stable execution of the above Plans.

Secondly, relevant departments should also improve the market-oriented mechanism to stabilize the income of new energy projects. First, the National Development and Reform Commission and energy management departments should optimize green power trading rules, expand green power transaction scope, facilitate industrial enterprises and data centers to purchase green power, clarify

the mechanism for premium on green power. We should further work on encouraging more enterprises to join into green power consumption. Besides, ancillary service market mechanism should be set up including energy storage and virtual power plants to take in peak load and frequency regulation services, and new energy projects participating in ancillary services from the establishment of revenue distribution rules. Such as wind and PV power stations, when the energy storage systems provide peak load regulation service, they can take additional revenue according to the peak load regulation amount, and avoid losses caused by unstable power generation, so that new energy projects through replacing a single income from power generation with diversified (power generation + ancillary services) income.

4.2 Technological Level

First of all, research institutions should work with new energy enterprises to carry out R & D of core technologies and break through efficiency and cost bottlenecks. In the 2023 PV power field, we must take key core components as the primary direction to achieve higher conversion efficiency, including continuously optimizing top-contact and heterojunction high-efficiency PV cells processes [7] and pushing for commercial implementation of perovskite-crystalline silicon tandem cells (the actual large-scale production capacity that can be turned into practice from the laboratory conversion efficiency). Secondly, the development of a low-cost PV material should continue to reduce the production cost of PV modules by 10% to 15%, which includes silver-free pastes or thin silicon wafers. Wind Power Generation: they need to tackle the core components of large-scale units, for example, comprise high-strength blades (with carbon fiber composites) used in 20 MW and above wind turbines; high-reliability bearings (to break import dependence); and intelligent controls systems to minimize, reducing intermittent downtime due to key component failure, concurrent with fine-tuning the aerodynamic design of wind turbines for efficient power generation in low-wind-speed regions. In addition, it should also research and develop more efficient combustion power generation and heat exchange technologies for small type new energy sources, such as gasification coupled power generation technology for biomass energy production to enhance the power generation efficiency from 25% on the current level to beyond 30%, thereby reducing the cost of replacing traditional fossil fuels.

Second, new energy enterprises need to work with technology companies to further deepen the penetration of intelligent technologies in power generation and business efficiency. Introduce artificial intelligence algorithms and big data analysis technologies in the power generation forecasting stage. Such as, a lot of the high-precision power forecasting model needs to build based on historical power generation data + meteorological satellite cloud images + real-time wind speed and solar radiation data so that the short-term forecasting accuracy of wind and solar reaches above 90%, and medium- and long-term forecast precision is above 85% to provide accurate basis for grid dispatching. Promote the application of digital twins and intelligent devices in the power station operation stage. Digital twin systems should be built for the PV and wind power stations to imitate the real-time running status of units and warn potential failures [8]. By using UAV to inspect wind turbine blades and robot to clean PV panels (i.e., it replaced the manual operation), the operational efficiency is increased by >30% and fault handling time is shortened within 2 hours. At the same time, we should promote the combination of new energy and internet of things (IoT) technology, for example: smart meters and communication modules are installed in distributed PV power stations to realize real-time uploading of electricity generation and consumption data, so that users or grid enterprises can settle accounts accurately through accurate reading terminals by the machine; When surplus power enters the grid, it can also avoid data deviation in grid connection.

5. Conclusion

Therefore, new energy power generation in China has implicitly changed from a supplementary power source to the main power source in electric power construction; its predominant status in rectifying and determining the energy structure, securing national energy security ability and fabricating large-scale thermal coal reserve also has proved itself practicably. Proportion of

non-coal power generation surpassed 30% for the first time in 2024; output value of renewable energy equipment manufacturing exceeded RMB3 trillion Yuan; distributed PV on rooftops in the east and wind-PV bases in the west made up more than 100 billion kilowatt-hour regional power deficit to support x low-carbon change electric power construction. As new energy power generation is still at the initial stage and faces multiple challenges at present, with the in-depth iteration of high-efficiency PV modules and long-duration energy storage technologies, as well as the construction of flexible DC transmission grids and the improvement of green power trading and ancillary service markets, it can be seen that electric power construction will be integrated into a more extensive complementarity with new energy power generation in future. In the future, it is necessary to further promote high quality development of new energy power generation in electric power construction through policy coordination and planning alignment and technological breakthrough of core bottlenecks.

References

[1] Sun Chao. Application and Development of New Energy Power Generation in Electric Power Construction [J]. Power Station Auxiliary Equipment, 2025, 46(1): 37-40.

[2] Li Shuai. Exploration of the Application Modes of New Energy PV Power Generation Technologies in Multiple Scenarios [J]. China Strategic Emerging Industry, 2025(21): 57-59.

[3] Hao Huilei. Research on the Development Strategy of S New Energy Power Generation Enterprise [D]. Shijiazhuang: Hebei University of Economics and Business, 2023.

[4] Cao Yu. Application of New Energy Power Generation in Power Systems [J]. Electronic Technology & Software Engineering, 2019(21): 227-228.

[5] Song Zhengkun. Current Situation and Construction of China's Electric Power Market [J]. Electrical Age, 2016(8): 20-21.

[6] Xu Longbo. Strategic Thinking on the Development of Large-Scale Electric Power Design Institutes in the Field of New Energy Power Generation [J]. Southern Energy Construction, 2016, 3(1): 58-62+69.

[7] Wang Yan, Wu Dacheng. The Role of New Energy Power Generation in Electric Power Construction in Qinghai Province [J]. Qinghai Science and Technology, 2000(4): 36-37+51.

[8] Zhang Zhilong, Sun Jiuren. Discussion on the Applicability of New Energy Power Generation in Electric Power Construction in Remote Rural and Pastoral Areas [J]. Renewable Energy Resources, 1993(5): 20-21.