Study on China's New Energy Development Trend through Achieving the Consumption Proportion Target for Non-fossil Energy

Mengxuan Lv [1, a], Bo Yuan [1, b], Haitao Chen[1, c], Chenglong Zhang[1, d]

[1] State Grid Energy Research Institute Co., Ltd., Beijing, China.

[a] lvmengxuan@sgeri.sgcc.com.cn, [b] yuanbo@sgeri.sgcc.com.cn, [c] chenhaitao@sgeri.sgcc.com.cn,

[d] zhangchenglong@sgeri.sgcc.com.cn

Abstract. Recently, the Statistical Communiqué of the People's Republic of China on the 2022 National Economic and Social Development (hereinafter referred to as "Communiqués") was published by the National Bureau of Statistics. According to the Communiqués, China's total primary energy consumption in 2022 amounted to 5.41 billion tons of standard coal. It is projected that by 2025, the total energy consumption will reach approximately 5.84-6.04 billion tons of standard coal. In order to meet the target of non-fossil energy consumption accounting for 20% of total energy consumption by 2025, the installed new energy capacity within operating areas of State Grid Corporation of China is anticipated to exceed the previous estimate by 100-140 million kilowatts. From a risk assessment standpoint, the research team has constructed an evaluation model to gauge China's new energy development trend, taking into account the accomplishment of the consumption proportion target for non-fossil energy. They delve into the issues brought about by the unexpected development of new energy and put forth pertinent measures to tackle them.

Keywords: Communiqués; total energy consumption; new energy capacity; pertinent measures.

1. Introduction

Recently, the Statistical Communiqué of the People's Republic of China on the 2022 National Economic and Social Development (hereinafter referred to as "Communiqués") was published by the National Bureau of Statistics. In light of the data presented in the Communiqués, the research team conducted a thorough analysis. The initial findings suggest that the development trend of total energy consumption is poised to exert a significant chain effect on the new energy development scale outlined in China's "14th Five-Year Plan" for Renewable Energy Development. According to the Communiqués, China's total primary energy consumption in 2022 amounted to 5.41 billion tons of standard coal, with non-fossil energy consumption accounting for 17.5% of the total. It is projected that by 2025, the total energy consumption will reach approximately 5.84-6.04 billion tons of standard coal (including energy consumption of approximately 500 million tons of standard coal as raw materials). The achievement of the 20% target for non-fossil energy consumption proportion may be influenced by the new energy development scale outlined in China's "14th Five-Year Plan" for Renewable Energy Development.

Specifically, in order to meet the target of non-fossil energy consumption accounting for 20% of total energy consumption by 2025, the installed new energy capacity within operating areas of State Grid Corporation of China is anticipated to exceed the previous estimate by 100-140 million kilowatts. From a risk assessment standpoint, the research team has constructed an evaluation model to gauge China's new energy development trend, taking into account the accomplishment of the consumption proportion target for non-fossil energy. They delve into the issues brought about by the unexpected development of new energy and put forth pertinent measures to tackle them.

2. Evaluation Model for New Energy Development Trend

Based on the research conducted for 2025 and taking into account the projected total energy consumption and the national target for the proportion of non-fossil energy consumption, it

becomes possible to ascertain the total consumption of non-fossil energy. The projected total energy consumption is derived through the utilization of the Power Supply and Demand Economy-Energy-Electricity-Environment (4E) model independently developed by the State Grid Energy Research Institute. By subtracting the consumption of non-fossil energy for non-electric purposes, the quantity of non-fossil energy utilized for power generation can be determined. Furthermore, by subtracting the consumption of non-fossil energy for hydroelectric, nuclear power, and biomass power generation, the consumption of non-fossil energy for wind power and solar power generation is ascertained. Consequently, the installed capacity can be calculated, taking into account the utilization hours. The formulas for the evaluation model of the new energy development trend are as follows.

$$E_n = E_s * \rho$$

$$E_{nf} = E_n - E_{nn}$$

$$E_{nfe} = E_{nf} - E_{nft}$$

$$C_{nfe} = E_{nfe}/T_{nfe}$$

In which, E_s represents the total energy consumption; ρ represents the target proportion of non-fossil energy consumption, set at 20% for the year 2025; E_n represents the total consumption of non-fossil energy; E_{nn} represents the consumption of non-fossil energy for non-electric purposes, which accounts for approximately 5.4% of the total consumption of non-fossil energy in 2025 and is comparable to the average level between 2015 and 2021; E_{nf} represents the consumption of non-fossil energy for power generation; E_{nft} represents the consumption of non-fossil energy for hydroelectric, nuclear, and biomass power generation, totaling approximately 580 million tons of standard coal in 2025; E_{nfe} represents the consumption of non-fossil energy for new energy power generation; T_{nfe} represents the utilization hours for new energy power generation, estimated to be around 1,600 hours in 2025; C_{nfe} represents the installed capacity for new energy power generation.

3. Study on Total Energy Consumption and New Energy Development Scale by 2025

The projected total energy consumption in 2025 is expected to significantly surpass previous estimates, with an estimated range between 5.84 and 6.04 billion tons of standard coal. In 2022, a combination of factors, such as extreme weather conditions requiring heightened electricity utilization for cooling and heating, an increased proportion and improved energy utilization in the secondary industry, contributed to a total energy consumption of 5.41 billion tons of standard coal[1]. This marked a rise of 150 million tons compared to 2021 (including energy consumption of approximately 400 million tons of standard coal as raw materials), representing an increase of around 30 million tons of standard coal compared to 2021. Taking into account factors such as economic development, industrial restructuring, and adjustments of dual control assessment method for energy consumption, the projected total energy consumption in 2025, derived through the utilization of the Power Supply and Demand Economy-Energy-Electricity-Environment (4E) model, is anticipated to fall within the range between 5.84 and 6.04 billion tons of standard coal (including energy consumption of approximately 500 million tons of standard coal as raw materials), significantly surpassing the previous estimate of 5.6-5.7 billion tons of standard coal.

Due to the unexpected surge in total energy consumption, it is anticipated that the new energy development scale may significantly surpass the targets outlined in China's "14th Five-Year Plan" for Renewable Energy Development in order to achieve the 20% non-fossil energy consumption target[2]. If we reversely calculate the proportion of non-fossil energy consumption to be 20% based on the projected total energy consumption of 5.94 billion and 6.04 billion tons of standard

coal in 2025, the installed new energy capacity nationwide and within operating areas of State Grid Corporation of China will reach approximately 1.18 billion, 1.00 billion, 1.22 billion, and 1.04 billion kilowatts, respectively. These figures exceed the originally estimated scales by 130 million, 100 million, 170 million, and 140 million kilowatts, respectively.

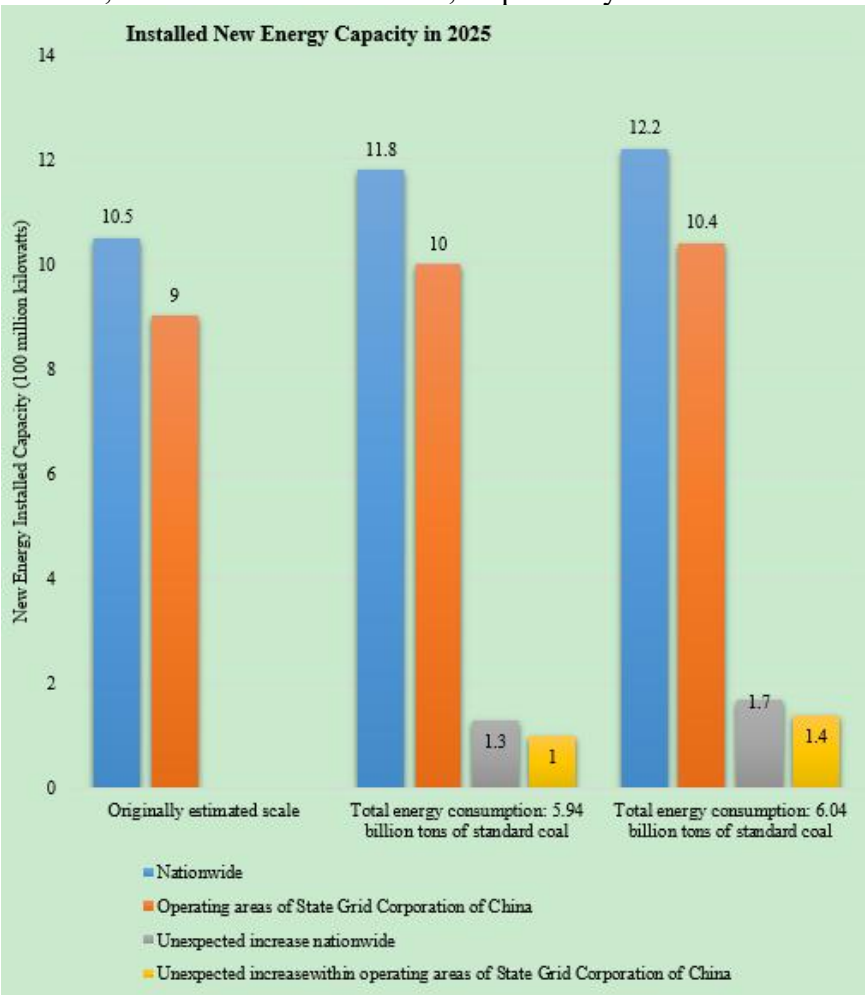

Fig. 1 Installed New Energy Capacity in 2025 under Different Scenarios

The aforementioned research incorporates energy consumption as raw materials when calculating the proportion of non-fossil energy consumption. However, if this energy consumption is excluded, the demand for new energy development outlined in China's "14th Five-Year Plan" for Renewable Energy Development will remain consistent with the originally estimated scale. It is worth noting that energy consumption as raw materials is not included in the total energy consumption control[3], in accordance with scientific assessment requirements. Nevertheless, when calculating the proportion of non-fossil energy consumption in the Communiqués, the energy consumption as raw materials is still included in the total energy consumption. Considering the projected total energy consumption of 5.94 billion tons of standard coal in 2025, if the energy consumption as raw materials is not included in accordance with scientific assessment requirements, the total energy consumption would decrease by approximately 500 million tons of standard coal, resulting in a total of 5.44 billion tons of standard coal. In line with the new energy development scale outlined in China's "14th Five-Year Plan" for Renewable Energy Development, the proportion of non-fossil energy consumption would reach 20.7%, exceeding the targeted 20%.

4. Major Issues Arising from the Unexpected Development of New Energy

Issues of optimizing the development mode and layout of unexpected new energy development[4]. The unexpected increase in installed capacity within operating areas of State Grid

Corporation of China ranges from 100 to 130 million kilowatts, necessitating immediate attention to optimize factors such as development and construction conditions, consumption conditions, and the layout between the western and northern regions and the eastern and central regions. It is imperative to facilitate the harmonized and coordinated development of diverse forms of new energy generation, encompassing onshore and offshore wind power, centralized and distributed photovoltaic systems, solar thermal power, and more. This approach will directly influence the challenges related to grid connection and transmission channel construction, as well as the utilization rate of new energy and fluctuations in system costs.

Issues of planning and construction of grid connection systems and trans-provincial and inter-regional transmission channels. In light of the "14th Five-Year Plan", the unexpected development of new energy necessitates the timely completion of channels included in China's "14th Five-Year Plan" for the Power Sector to address the transmission and consumption issues of new energy. Looking ahead in the medium to long term, as new energy expands into remote and less accessible regions, it is crucial to commence the planning and construction of additional transmission channels, along with the planning and feasibility studies for supporting regulatory and backup power sources.

Issues of setting reasonable utilization rate targets for new energy under the requirement of integrating quantity and utilization rate. Based on calculations, taking into account the installed new energy capacity of 1 billion kilowatts within operating areas of State Grid Corporation of China by 2025 and maintaining consistent system regulation capability as outlined in China's "14th Five-Year Plan" for the Power Sector, the overall utilization rate of new energy within operating areas of State Grid Corporation of China is estimated to decline to approximately 93%, with the Northwestern and North China regions falling below 90%. It is imperative to optimize the deployment of new energy based on the bearing capacity of grid system and establish a location-specific mechanism for the rational utilization rate of new energy.

Issues of increased system costs and pressure on end-user electricity prices for new energy. Based on calculations, taking into account the installed new energy capacity of 1 billion kilowatts within operating areas of State Grid Corporation of China by 2025, the associated system costs are projected to be around RMB 0.2/kWh. This represents an increase of approximately RMB 0.05/kWh compared to the estimated levels for the national and State Grid Corporation of China planning. Even if the reduction in station costs is taken into account, the projected end-user utilization cost of new energy is around RMB 0.54/kWh, which exceeds that of coal-fired power by approximately RMB 0.14/kWh. It is of utmost importance to promote the scientific allocation and mitigation of new energy system costs, as well as effectively control the rise in end-user electricity prices[5].

5. Study on Response Measures

Guiding the scientific planning and layout of new energy projects. In terms of national-level layout, it is crucial to give priority to the development of distributed new energy and offshore wind power in the near to medium term. This approach will guide the new energy layout towards the eastern and central regions. Based on calculations, taking into account the installed new energy capacity of 1.04 billion kilowatts within operating areas of State Grid Corporation of China by 2025, it is necessary to reduce the installed new energy capacity by 10 million kilowatts in the Northwestern region and increase it by 30-40 million kilowatts in the East China region in order to maintain a consistent overall utilization rate within operating areas of State Grid Corporation of China. In terms of national-level layout, it is recommended to prioritize the allocation of new projects to load centers, thereby easing the pressure in regions that are currently under significant strain.

Making efforts to ensure the construction of access system projects and the planning and construction of inter-regional power transmission channels. Make full use of the remaining capacity

of existing booster stations and leverage the current grid access conditions to reduce the need for constructing new supporting grid projects. Monitor closely the arrangements for the construction of supporting new energy projects in inter-regional transmission channels, ensure the construction progress of channels included in China's "14th Five-Year Plan" for the Power Sector, and guard against social concerns arising from the limited transmission and consumption of new energy due to grid-source mismatch. Combine the planning and layout of large-scale wind and solar power bases, proactively plan for additional transmission channels, and implement adjustable and supportive power sources in advance.

Placing emphasis on enhancing the power system's flexibility in regulation and driving the implementation of a rational mechanism for utilization rate improvement[6-7]. Accelerate the transformation of thermal power plants to improve their flexibility, incentivizing such transformation through market-based approaches like peak shaving support services and peak load capacity markets. Ensure the rational allocation and utilization of new energy storage, and promote the establishment of diversified revenue channels and multi-level market mechanisms that align with the development of new energy storage. Advocate for the government's scientifically determined scale, layout, and timing of new energy development, as well as the formulation of rational utilization rate targets that consider factors such as the proportion of new energy generation and the weight of non-hydro consumption responsibilities. Priority should be given to pilot projects in regions with high consumption pressure, such as the northwest and north China regions.

Accelerating the development of solar thermal power generation in the western and northern regions, while strengthening self-balancing capability of power generation and consumption units in the eastern and central regions. In the centralized development model of new energy, explore to expedite the development of solar thermal power generation that combines synchronous generators with energy storage functions. In the short term, the solar thermal scale is optimized primarily based on peak shaving requirements, integrating it with wind power and photovoltaics to form multi-energy complementary integrated projects. In the medium to long term, as the cost of electricity continues to decrease and the utilization hours increase, solar thermal power will gradually replace coal-fired power as a backup source, partly assuming the base load and partly participating in system regulation. In the decentralized development mode, additional flexible resources such as energy storage are being deployed to mitigate the overall output fluctuations of distributed new energy through "self-balancing", achieving local balance and reducing the demand for transmission capacity within the main grid. In cases where backup support is needed from the main grid, it becomes crucial to establish clear standards for charging rates and determine the responsibilities for backup capacity.

Studying and developing cost determination mechanisms and plans for the new energy system. Taking into account the cost level of the new energy system, efforts are being made to design appropriate capacity compensation and market mechanisms, as well as transaction options, to ensure equitable cost sharing among market participants, including new energy companies and electricity users. To tackle challenges such as increased grid investment costs and decreased utilization rates of transmission lines due to the grid connection and transmission of new energy, it is necessary to further enhance the pricing mechanism for transmission and distribution tariffs. Additionally, the development of new energy services should be considered within the purview of policy-driven investments, enabling a fair assessment of grid investment efficiency and the establishment of a scientifically determined scale for grid investments.

6. Suggestions

Taking into account the policy's explicit exclusion of energy consumption as raw materials from the total energy consumption control, it is advisable for China to further refine and specify the calculation methodology for determining the proportion of non-fossil energy consumption. This

should include the exclusion of energy consumption as raw materials when assessing the proportion of non-fossil energy consumption.

Regardless of historical experience or expert analysis, there is a high probability that the new energy scale will surpass the planned targets by 2025. Therefore, it is advisable to intensify the study on scenarios involving unexpected new energy development and implement measures to address the situation in advance.

Acknowledgments

This research was financially supported by Technology research services project of State Grid Corporation of China (SGCC) “Promote key technology research support for the implementation of dual-carbon targets”, sub-project “Study on system regulation capacity and new energy consumption”.

References

[1] Statistical Communiqué of the People’s Republic of China on the 2022 National Economic and Social Development.

[2] 14th Five-Year Plan” for Renewable Energy Development.

[3] Notice on Excluding Energy Used as Raw Material from Total Energy Consumption Control (F.G.H.Z.[2022] No. 803).

[4] HUANG Bibin, ZHANG Yunzhou, WANG Caixia. New energy development and issues in China during the 14 th five-year plan[J].Electric Power, 2020, 53(1): 1–9.

[5] ZHANG Yunzhou, WANG Caixia, et al. Methodology for Calculating VRE Equivalent Feed-In Tariff Based on System Cost and Its Application[J]. Electric Power, 2022, 55(2): 1–8.

[6] YUAN Wei, WANG Caixia, LI Qionghui, et al. Multi-area two-stage optimal allocation method of large-scale energy storage for renewable energy consumption[J]. Journal of Global Energy Interconnection, 2021, 4(4): 393–400.

[7] WANG Caixia, SHI Zhiyong, LIANG Zhifeng, et al. Key technologies and prospects of demand-side resource utilization for power systems dominated by renewable energy[J]. Automation of Electric Power Systems, 2021, 45(16): 37–48.