Analysis on the Current Situation and Development Trend of China's Electrification Level and Electric Energy Substitution under the Background of Carbon Neutral

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Abstract. There is still room for improvement in China's electrification level, and power substitution is an important grasp to improve the level of electrification. The implementation of electric energy substitution can promote energy transformation, realize green development and support the realization of carbon neutral goal. After analysis, the power substitution is still the main force to improve the level of electrification in various fields during the "14th five year plan".

Keywords: Power substitution; Electrification level; Carbon neutralization; Development trend.

1. Introduction
On September 22, 2020, President Xi Jinping delivered an important speech at the general debate of the seventy-fifth UN General Assembly, and put forward that China will enhance its national independent contribution and adopt more effective policies and measures. CO2 emission will strive to reach its peak by 2030, and strive to achieve carbon neutralization by 2060. At the 2015 Paris conference, China promised to "peak CO2 emissions around 2030 and strive to reach the peak as soon as possible". The carbon peaking and carbon neutralization targets have a great impact on the energy industry, which means that China's low-carbon transformation needs to be accelerated. We must speed up the adjustment of energy structure, reduce fossil energy consumption and improve energy efficiency. It is of great significance to improve the level of electrification and vigorously implement electric energy substitution.

There are many researches on power substitution, such as references [1-5], which have been carried out from different angles. The energy saving mechanism of electric energy substitution is revealed in reference 1. References 2 and 3 analyze the current situation of power substitution in Tianjin and Anhui Province. Literature 4 looks forward to the power substitution under the background of Internet, and document 5 analyzes the promotion mode of rural power substitution. The research focus of this paper is to study the power substitution from the perspective of electrification level and emission reduction, summarize the current situation and predict the future trend.

2. Analysis of Electrification Level
Since the reform and opening up, China's electrification level has been continuously improved. In 2018, China's electric energy accounted for 25.5% of terminal energy consumption, an increase of 21.1 percentage points compared with 1980.
In terms of sectors, the electrification levels of industry, transportation, commerce, residents and other industries in 2018 were 30.4%, 3.5%, 36.8%, 24.7% and 20.6%, respectively, which were 21.3, 2.6, 36.8, 24.3 and 10.5 percentage points higher than those in 1980. Among them, the level of industrial and residential electrification is at the middle level in the world, while the level of commercial electrification is backward in typical countries. From the perspective of different regions, the level of electrification in eastern China is higher than the global average. Zhejiang, Guangdong, Jiangsu and Beijing, which rank the top, have rapid industrial transformation. The economic structure is dominated by light chemical industry, equipment manufacturing and tertiary industry, and the level of electrification is relatively high. The level of electrification in Northeast China lags far behind that of developed countries, and there is a large space for development. From the per capita electricity consumption, there is a certain gap between China's electrification level and developed countries. In 2019, the per capita power consumption of the United States is as high as 12700 kwh / person, that of the European Union is 6300 kwh / person, and that of China is about 5200 kwh / person, less than half of that of the United States.

There is still much room for improvement in China's electrification level. In order to achieve the goal of carbon emission reduction, the proportion of non fossil energy in primary energy must exceed 50%, and that of electric energy in terminal energy consumption should exceed 50%.

3. Electric Energy Substitution is an Important Means to Improve the Level of Electrification

From the perspective of high-quality economic development, China's economic development has entered a new era, from the stage of high-speed growth to the stage of high-quality development. The traditional resource advantages of some regions have weakened, and the urgent demand has shifted to high-quality development. Electric energy is a high-quality and efficient secondary energy. Its economic value is equivalent to 17.3 times of the equivalent equivalent coal and 3.2 times of the oil. Each percentage point increase in the proportion of electric energy consumption in the final energy consumption will reduce the energy intensity by 3.7%. The implementation of power substitution project can enhance the competitiveness of industry products, improve total factor productivity, and boost the formation of high-end industrial value chain.

From the perspective of energy security development, China's oil and gas resources have been relying on imports for a long time. The dependence of crude oil and natural gas on foreign countries has reached 70% and 45%, respectively, and will show a further upward trend. China is rich in new energy resources such as scenery and has great potential for development. Promoting the large-scale transformation of new energy into electric energy development and utilization will help to improve the level of energy self-sufficiency. Improving the electrification rate of terminal energy consumption, giving full play to the advantages of China's energy resource endowment, and using renewable energy and clean coal to meet the terminal power demand will effectively improve the level of energy security.
From the technical point of view, the new technological revolution promotes the adjustment of industrial structure and boosts the development of energy integration based on electricity. The application of new generation science and technology represented by cloud computing, big data, Internet of things, mobile Internet and artificial intelligence not only promotes the improvement of energy efficiency and the safe and stable operation of power system, but also greatly promotes the adjustment of industrial structure.

With the rapid development of ICT and iterative upgrading of chips and software, it is widely used in high-end CNC machine tools, electric vehicles, electric ships, electric boilers, electric kilns and other fields. With its advantages of intelligent measurement and control, it helps to realize the replacement of traditional production and lifestyle by electric production and promote the high-quality development of industry.

From the perspective of ecological and environmental protection, China's carbon emissions will account for 28% of the global total in 2019, and the pressure of emission reduction will be great. The Central Committee of the Communist Party of China comprehensively deployed and promoted the work of energy revolution. General Secretary Xi proposed the "two mountains theory", which requires the clean, electrified and intelligent development of terminal energy consumption. Recently, China has put forward the goal of carbon neutrality. The fundamental way to realize the revolution of energy consumption is to establish an energy structure with non fossil energy as an important source and power as the center, and accelerate the substitution of electric energy, which can effectively relieve the pressure of emission reduction, greatly improve China's energy efficiency level and reduce the dependence on oil and gas imports.

4. Current Situation of Electric Energy Substitution

The number of electricity substitutes has increased year by year, and the field of substitution has been expanded from the original 5 categories to 21 categories and 57 subdivision technologies.

It is estimated that during the 13th Five Year Plan period, electricity substitution will increase the proportion of terminal energy consumption of electric energy by 2.8%. According to the "2019 annual report on China's policies and actions to cope with climate change" issued by the Ministry of ecology and environment, China's carbon dioxide emissions per unit of GDP in 2018 decreased by 4.0% compared with the previous year and 45.8% lower than that in 2005, realizing the commitment of reducing carbon intensity by 40-45% in 2020 compared with 2005. It is estimated that the contribution of electricity substitution to the decline of carbon intensity in China is more than 30%.

5. "The Fourteenth Five Year Plan" Electric Energy Substitution is Still the Main Force to Improve the Level of Electrification

The alternative development of electric energy is facing great opportunities. To ensure national energy security, new requirements are put forward for electric energy substitution. The development of new energy and energy Internet provides a solid foundation for power substitution. Energy revolution and "new infrastructure" bring development opportunities for power substitution. The rapid development of new technologies such as hydrogen production by electricity provides power for the substitution of electric energy. National and local governments have issued a large number of supporting policies,
including 31 policies (3 at the national level) in the first half of 2020. Hydrogen energy has broad application prospects in the future, not only in the field of fuel vehicles, but also in aerospace, metal smelting, food processing, chemical production and many other fields. Driven by policy and technology, during the "14th five year plan" period, the potential of electric energy substitution is still large, which is the cornerstone of China's electrification level improvement.

Power substitution can improve the level of industrial electrification. Industry is the key field of electric energy substitution, which is of great significance to carbon reduction. For example, the iron and steel industry is one of the pillar industries in China. The carbon emission of China's steel industry reaches more than 1 billion tons every year, accounting for about 15% of the total carbon emission of the country. It is the manufacturing industry with the highest carbon emission in China. According to incomplete statistics, 2.5t carbon dioxide will be emitted by blast furnace process for every 1t steel production, about 2.2t CO₂ emission per ton steel produced by converter, and 0.5t CO₂ emission from electric arc furnace process. China is the world's largest steel producer, and the European Union said it would consider imposing a carbon border regulation tax on Chinese steel products if the carbon cost of China's steel industry was too low. Therefore, it is of great significance for the healthy development of industry to carry out the work of electric energy substitution. In terms of technology, industrial electric kilns are conducive to improving product quality and production efficiency without pollutant emission; electric boilers have excellent environmental protection performance, outstanding technical advantages, insufficient economy, rapid adjustment and accurate temperature control. The main alternative work is to promote the direct heating electric boiler technology such as inductance type and resistance type in the fine chemical industry, pharmaceutical industry and precision electronics industry; actively promote the heat transfer oil electric boiler technology in the wood processing and furniture manufacturing industries; and focus on the promotion of continuous operation electricity such as mesh belt furnace, chain casting furnace, rolling rod furnace, single row and multi row pusher furnace and large drum furnace in the automobile manufacturing industry. In the metal casting industry, promote high-power medium frequency smelting furnace technology; in the high-end process ceramic manufacturing industry, promote electric double push double hole energy-saving tunnel kiln.

Power substitution can improve the level of agricultural electrification and help rural revitalization. In terms of key technologies, the electric drying technology has a great market potential, and the cold chain logistics has a high market potential. The replacement work focuses on large-scale industrial clusters such as grain, mushroom, vegetables, seafood, etc., relying on typical pilot projects to carry out demonstration and lead, and promote the large-scale substitution of agricultural production bases and industrial clusters. At the same time, actively cultivate the electric agricultural machinery market, strive for subsidy policy, and constantly improve the level of agricultural and rural electrification.

Electrical energy substitution can improve the level of electrification in the construction field. In terms of technology, the air source heat pump project has high energy efficiency and the scope of application has gradually expanded. With the promotion of green energy-saving buildings, heat pump has become the most important alternative technology of electric energy in the construction field. The electric cool storage technology is the refrigeration technology with the lowest operating cost, and has a good market prospect in the field of industrial refrigeration and large-scale public buildings. The thermal storage electric boiler heating project is mainly used for the low valley price Or have preferential electricity price policy for wind abandonment. The replacement work mainly focuses on economic projects, vigorously promotes the application of electric heating technology such as large-scale water storage boiler and air source heat pump, innovates and creates the demonstration of electric heating in central heating station, and leads and drives the application of clean heating in South China.

Electric energy substitution can improve the level of transportation electrification and help build a transportation power. In terms of technology, the development of port shore power technology is gradually mature, and the ecological and environmental benefits are significant. If the market is mature and reasonable service charge price is gradually formed, the economy of shore power will be improved and improved; with the decrease of power battery cost, the economy of pure electric ship will gradually appear; the electric vehicle industry will grow rapidly in the future, and its position in the electric energy substitution market will become more and more important. The main alternative work is to improve the network of electric vehicle charging station, realize the interconnection of charging services, build the
integrated network of shore power service in the whole basin, realize the interconnection and sharing of
shore power information, and actively pilot the application of electric ship technology.
In terms of technology, under the same output, the electric kitchen cooking technology has the
advantages of low energy consumption, low cost, short payback period and good economy, which is
suitable for wide promotion in commercial catering and residential families, and has great potential in
the future electric energy substitution market. The alternative work mainly includes implementing clean
heating into the campus, promoting electric kitchen cooking technology according to local conditions,
promoting campus traffic electrification, widely applying campus distributed renewable energy,
carrying out electric kitchen training, strengthening publicity and promotion with electric kitchen
manufacturers, and innovating the promotion mode of electric kitchen.
If the subsidy policy support of electric energy substitution is further strengthened, the environmental
restraint policy is strengthened, and the alternative technology is further broken through, the power
substitution will reach more than 500 billion kwh, and the proportion of electric energy in the terminal
energy consumption will be increased by 1.7%.

6. Conclusion
There is still room for improvement in China's electrification level. Electric energy substitution is an
important grasp of electrification promotion. In the future, power substitution is still an important
support for electricity consumption growth. In the context of carbon neutral, power substitution will
play an important role.

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