Current situation and trend analysis of electrification level of terminal energy consumption

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Abstract. Under the background of carbon neutral, improving the level of terminal electrification can promote the use of clean energy and improve the efficiency of energy use, which is an important means to accelerate the low-carbon transformation of energy, promote the sustainable development of economy and society, and achieve the goal of "carbon peak, carbon neutral". This paper analyzes the current situation of China's terminal electrification level from different dimensions, analyzes the development trend of these factors, and forecasts the future terminal electrification level through qualitative analysis of influencing factors and data calculation.

1. Introduction
The proportion of electric energy in China's terminal energy consumption has gradually increased. According to the energy statistical yearbook data, the proportion of electric energy in terminal energy consumption in 2018 was 24.6%, which was 10.1 percentage points higher than that in 2000, showing a gradual growth trend. Due to the lag of energy statistical data, the latest energy statistical yearbook is 2018, and the data of 2019 and 2020 are lagging behind. It is predicted that electric energy will account for about 26% of terminal energy consumption in 2019. The electrification rate in 2020 may be about 27%. The data of electrification level in China in recent years is shown in Figure 1.

![Figure 1. Proportion of electric energy in China's terminal energy consumption since 2000.](image_url)

From the perspective of subsectors, the level of commercial and industrial electrification is high, while the level of transportation electrification is the lowest. The level of commercial electrification increased fastest, ranking first, while the level of transportation electrification increased slowly, ranking last, and the level of industrial electrification has always been in the leading position.

From the regional point of view, there are obvious differences in the level of regional terminal electrification. The electrification level of each region has been improved year by year, and the eastern region has the highest and fastest electrification level, while the northeast region has the lowest and slow electrification level. In 2018, the proportion of terminal power consumption in eastern, central,
Western and Northeast China was 26.6%, 20.1%, 21.6% and 14.0% respectively, which increased by 6.1%, 3.8%, 4.7% and 1.7 percentage points respectively compared with 2010.

From the perspective of provinces, the causes of the level of terminal electrification are different. In 2018, the terminal electrification level of Zhejiang Province and Guangdong Province was the highest, reaching 37.6% and 33.4% respectively; Zhejiang, Guangdong, Jiangsu and Beijing, which are ranked in the top, have earlier industrial transformation, and relatively few heavy industries use coal and oil as energy and raw materials. Therefore, the level of electrification is higher and the power consumption per unit GDP is lower. Qinghai, Gansu, Xinjiang, Ningxia and other provinces with relatively weak economy maintain a high level of electrification, which is mainly due to the high power consumption industry pulling up the power consumption level. The electrification level data for each province are shown in Table 1.

### Table 1. Energy consumption of each province in 2018.

| Province (city) | Total terminal energy consumption (10000 tons of standard coal) | Coal (10000 tons of standard coal) | Petroleum (10000 tons of standard coal) | Natural gas (10000 tons of standard coal) | Electric power (10000 tons of standard coal) | Proportion of electric energy in terminal energy consumption (%) |
|----------------|----------------------------------------------------------------|-----------------------------------|----------------------------------------|------------------------------------------|---------------------------------------------|---------------------------------------------------------------|
| Zhejiang       | 14311                                                          | 1931.7                            | 3651.1                                  | 1331.6                                   | 5375                                        | 37.6                                                           |
| Guangdong      | 22315.9                                                        | 3744.3                            | 9018.6                                  | 1156.2                                   | 7463.4                                      | 33.4                                                           |
| Qinghai        | 2781.4                                                         | 657.2                             | 419.7                                   | 672.8                                    | 874.7                                       | 31.4                                                           |
| Jiangsu        | 23916                                                          | 7989.6                            | 4470.7                                  | 1850.5                                   | 7308.9                                      | 30.6                                                           |
| Fujian         | 9004.7                                                         | 2682.6                            | 2651                                    | 507.1                                    | 2751.1                                      | 30.6                                                           |
| Gansu          | 5233.1                                                         | 1780                              | 1037.7                                  | 389.2                                    | 1511.5                                      | 28.9                                                           |
| Shandong       | 28633.6                                                        | 8956.4                            | 4892.3                                  | 2034.8                                   | 8088.1                                      | 28.2                                                           |
| Xinjiang       | 12026.4                                                        | 3442.3                            | 2080.3                                  | 1447.4                                   | 3566.9                                      | 27.9                                                           |
| Henan          | 15410.2                                                        | 5503                              | 3402.1                                  | 1263.3                                   | 4200.3                                      | 27.3                                                           |
| Ningxia        | 4832.7                                                         | 2611.8                            | 398                                     | 212.8                                    | 1278.1                                      | 26.4                                                           |
| Guangxi        | 7765.9                                                         | 3231.6                            | 1613                                    | 285.6                                    | 2032.9                                      | 26.2                                                           |
| Inner Mongolia | 16514.3                                                        | 8476.9                            | 1616.5                                  | 784.2                                    | 4012.6                                      | 24.3                                                           |
| Beijing        | 5480.7                                                         | 86.9                              | 2433.4                                  | 896.9                                    | 1318.7                                      | 24.1                                                           |
| Shaanxi        | 8553.4                                                         | 3382                              | 1335.1                                  | 1168.2                                   | 2059.6                                      | 24.1                                                           |
| Guizhou        | 7210.5                                                         | 3446.8                            | 1647                                    | 392.7                                    | 1689.2                                      | 23.4                                                           |
| Jiangxi        | 7273                                                           | 3394.9                            | 1723.7                                  | 325.1                                    | 1662.1                                      | 22.9                                                           |
| Yunnan         | 8467.3                                                         | 4294.5                            | 1954.7                                  | 150.9                                    | 1916.2                                      | 22.6                                                           |
| Shanghai       | 8215.6                                                         | 457.3                             | 4800.3                                  | 810.3                                    | 1832.9                                      | 22.3                                                           |
| Hainan         | 1789.9                                                         | 177.7                             | 649.5                                   | 549.2                                    | 377.5                                       | 21.1                                                           |
| Chongqing      | 6155                                                           | 2075.4                            | 1346.6                                  | 1272.5                                   | 1291.7                                      | 21                                                             |
| Shanxi         | 13183.4                                                        | 7680.1                            | 1149                                    | 664.7                                    | 2673.6                                      | 20.3                                                           |
| Hubei          | 12713.9                                                        | 5075.3                            | 3885.2                                  | 719.6                                    | 2507.6                                      | 19.7                                                           |
| Sichuan        | 14174.9                                                        | 4383.2                            | 3374.7                                  | 2979                                     | 2783.5                                      | 19.6                                                           |
| Anhui          | 12765.3                                                        | 4265.1                            | 2262                                    | 3337.7                                   | 2470.7                                      | 19.4                                                           |
| Tianjin        | 6289.6                                                         | 1627.1                            | 2014.6                                  | 697.9                                    | 1086.9                                      | 17.3                                                           |
| Hunan          | 11686.4                                                        | 5604.8                            | 2827.4                                  | 404.7                                    | 1993                                        | 17.1                                                           |
| Hebei          | 29180.8                                                        | 18185.7                           | 1856.6                                  | 1779.1                                   | 4616                                        | 15.8                                                           |
| Liaoning       | 18300.5                                                        | 6841.3                            | 5557.8                                  | 956.3                                    | 2794.4                                      | 15.3                                                           |
| Jilin          | 5811.2                                                         | 2026.2                            | 1406.5                                  | 386                                      | 868.1                                       | 14.9                                                           |
| Heilongjiang   | 8020.8                                                         | 3064                              | 1642.7                                  | 513                                      | 1132.3                                      | 14.1                                                           |

Data source: China Energy Statistics Yearbook.
From the perspective of international situation, the proportion of global electric energy in terminal energy consumption shows a slow growth trend. It is estimated that the proportion of global electric energy in terminal energy consumption will be 19.6% in 2019. Overall, although the proportion of electric energy in terminal energy consumption in China is in the same range as that in developed countries, there is still a significant gap in the overall level. Among them, the industrial sector is 19 percentage points lower than South Korea, the residential sector is 3 percentage points lower than Japan, and the business sector is still lagging behind the global level.

2. Analysis on the necessity of improving the level of terminal electrification

China's carbon emissions are large. In 2019, China's carbon dioxide emissions from fossil energy combustion will be about 9.8 billion tons, accounting for about 30% of the world's total. The per capita emissions are 46% higher than the world average. China is the world's largest greenhouse gas emitter, and the international pressure of emission reduction is increasing. General secretary Xi Jinping put forward the energy strategy of "four revolutions and one cooperation". He stressed the importance of adhering to the concept of green development and promoting the sustainable development of the economy and society. In 2020, general secretary Xi Jinping put forward the goal of "carbon neutralization", forcing energy transformation. Developed regions and countries such as EU, UK, France and Germany have achieved the peak of carbon emissions from fossil energy combustion. It takes a long time from the peak to carbon neutralization, while China has only 30 years. We are faced with the problem of short time and urgent task to achieve our goal. Reducing the proportion of fossil energy on the supply side, implementing energy conservation on the energy consumption side, and increasing the proportion of electric energy in the terminal energy consumption are important measures to effectively reduce carbon emissions and achieve the goal of "carbon neutral". With the development of high proportion of renewable energy power system, the electrification of end use energy can effectively reduce the carbon dioxide emissions of industry, transportation, construction and other end use sectors.

Electrification, cleaning, low-carbon and intelligent become the direction of industrial structure adjustment and economic and social development [1]. Electric energy is a high quality and efficient secondary energy. The terminal utilization efficiency of electric energy is usually above 90%, while the terminal utilization efficiency of coal burning is generally not higher than 40%, and the efficiency of loose coal burning is generally lower than 20%; The utilization efficiency of fuel terminal is about 30%-40%, so the utilization efficiency of electric energy is obviously higher than that of fossil energy such as coal and oil. The research shows that the energy intensity will decrease by 2%-4% when the proportion of electric energy consumption in terminal energy consumption increases by 1%. Promoting the implementation of "clean electricity instead of coal" and "clean electricity instead of oil" in terminal energy consumption can improve product competitiveness, industrial added value and total factor productivity. Industrial technology will show the trend of digitalization and intelligence, and electrification is an insurmountable premise and foundation. Promoting the improvement of electrification level is conducive to fostering the development of new infrastructure such as energy internet, smart transportation, charging piles for new energy vehicles, big data centers and industrial internet, making use of building high value-added industrial chains and market formats, and promoting economic optimization and upgrading and high-quality development. In addition, driven by the national rural industry revitalization strategy, vigorously implementing rural electrification is conducive to consolidating achievements in poverty alleviation, improving rural ecological environment, promoting agricultural and rural development to improve quality and efficiency, and increasing farmers' production and income.

China's oil and gas resources have long been dependent on imports [2]. If the international geopolitical conflict intensifies, there are security risks in the source areas and transportation channels of imported energy, and the guarantee of energy supply is facing a major test. Large scale development of new energy is an inevitable requirement to realize the vision of carbon neutrality. New energy resources can be developed and utilized in the form of electric energy to improve the
Electrification level of energy consumption terminal, which can grasp the initiative of energy security. According to the calculation of relevant models of State Grid Energy Research Institute, if the level of electrification is increased by 1 percentage point, the energy external dependence is expected to decrease by 0.5-1 percentage point. Improving the level of electrification can not only carry the efficient transformation of new energy, but also promote the overall level of energy efficiency [3].

China is rich in coal, oil and gas, rich in renewable energy, and highly dependent on oil and gas [4-5]. At the same time, although China's economic volume has leaped to the forefront of the world, and its electrification level has ranked the world's leading level, the development among regions and statistical departments is uneven, and there is still a big gap compared with developed countries. In the future, economic development will maintain a rigid growth, therefore, there is still a large space for the development of China's electrification level.

3. Analysis of influencing factors

Energy resource endowment is the realistic basis for choosing the path of energy production and consumption transformation. According to the characteristics of their own resources, all regions carry out the effective development and utilization of energy.

The level of electrification is improved with the development of economy and society. Economic development has driven the growth of energy consumption. There is a positive correlation between the level of terminal electrification and per capita GDP. The level of electrification continues to improve with economic growth. Analysis of influencing factors is shown in Table 2.

| Influencing factors | Development trend |
|---------------------|-------------------|
| Economy             | China's economy has entered a stage of high quality development. After the basic completion of industrialization, it has entered a stage of stable development, the manufacturing industry has stridden forward to the middle and high end, and the proportion of modern service industry has increased significantly. With the continuous expansion of middle-income groups, personalized and diversified development oriented and service-oriented consumption has gradually become the mainstream. The pulling effect of consumption demand on economic growth will continue to expand. China's industrial structure continued to upgrade, emerging industries continued to develop rapidly, and the transformation and upgrading of high energy consuming industries accelerated. |
| Policy              | Under the background of carbon neutral, implement the policy of "double control" of energy consumption, formulate the action plan and roadmap of carbon peak in key industries, and introduce the carbon action plan in petrochemical, coal, steel, electric power, automobile, environmental protection, transportation and other industries. The introduction and implementation of energy related policies of terminal departments such as electric energy substitution and new infrastructure plays an important role in promoting the level of terminal electrification. |
| Technology          | Energy storage, heat / cold storage, electric vehicle and hydrogen energy will accelerate development. When the output of wind, light and other new energy is at peak and the electricity price is low, on the one hand, through market-oriented trading, new energy can be absorbed by replacing large-scale electric energy, on the other hand, electric energy can be transformed into various forms of energy "storage". When the output of wind, light and other new energy is insufficient and the electricity price is high, the stored energy is used. The cost of new energy supply will be reduced, the terminal electrification will be further promoted, and the energy utilization efficiency will be improved. |
Industrialization and urbanization are the basic elements to promote the level of electrification. With the acceleration of urbanization and industrialization, the increase of residents' disposable income promotes the upgrading of consumption structure, the continuous growth of electricity demand and the continuous improvement of electrification level.

The continuous optimization of industrial structure is helpful to promote the level of terminal electrification. The electrification level of service industry and high-end manufacturing industry is relatively high, and the increase of the proportion of corresponding industries will inevitably lead to the rise of the overall electrification level.

The power demand of digital economy industry is large, which drives the improvement of electrification level. The digital economy industry ushered in the accelerated development, which needs the support of electric energy. The intelligent level of electric power is higher than coal, oil, gas and other fossil energy, as the main energy to carry the "digital economy" operation.

Technological progress is not only an important force to promote the development of electrification, but also a necessary support to promote the process of electrification. Technological progress in the production side, such as power generation and supply, will promote the development of clean energy and promote the continuous improvement of the electrification level of the whole society. With the increasing maturity of new energy technology and the continuous improvement of system flexibility, the economy and competitiveness of wind power and photovoltaic power generation will continue to improve. On the end consumer side, technological progress reduces energy consumption per unit product and service, and promotes efficient and clean utilization of energy.

To a large extent, the degree of policy support determines the speed of increasing the proportion of electric energy. The higher the level, the higher the legal effect and the stronger the policy. Fiscal and tax subsidy policies, environmental mandatory constraints and other policies have played a direct positive role in promoting the proportion of electric energy.

4. Results and discussions

The terminal electrification level is obtained by dividing the electricity consumption by the total primary energy consumption. To study and judge the level of terminal electrification, the paper first forecasts the medium and long-term development of China's economy, taking the economic development scenario as the boundary condition. Then it forecasts the terminal energy demand of each department and the power demand. In demand forecasting, it is necessary to consider the necessary conditions for achieving the goal of carbon peak and carbon neutralization and the key influencing factors of supply side and demand side development in combination with the medium and long-term development trends such as economic and social development, energy and resource endowment, supply and demand pattern, technological progress and policy orientation.

Based on the above analysis and calculation, it is predicted that China's terminal energy consumption will reach its peak before 2030, and the proportion of electric energy in terminal energy consumption will continue to increase. It is estimated that electric energy will replace coal as the main energy of terminal consumption in 2025. The proportion of electric energy in terminal energy consumption will continue to rise, and it is expected to reach 32%, 37% and 70% respectively in 2025, 2030 and 2060.

5. Conclusions

This paper analyzes the current situation of China's terminal electrification level from different angles, and puts forward the key factors and development trend that affect the terminal electrification level. It is predicted that the terminal electrification level will reach 32%, 37% and 70% respectively in 2025, 2030 and 2060. Improving the level of electrification is conducive to the implementation of the "carbon neutral" goal. In the future, there is still much room to improve the level of electrification, which needs government support at the policy level and innovation breakthrough at the technical level.
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