Research on International Comparison and Future Development Trend of China's Electrification Level

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Abstract. Problems such as shortage of resources, environmental pollution, and climate change are increasingly becoming serious obstacles to the development of human society. To cope with these problems, a new round of energy transformation is in full swing, and electricity is playing an increasingly important role as a clean, efficient and convenient secondary energy source. In this paper, we compare China's electrification level with the global and 10 typical countries, summarize the development characteristics of global electrification level, analyze the current situation of China's electrification level. In the end, we comprehensively consider the factors affecting the electrification process, and combine relevant research to judge the development trend of China's electrification process in the future.

1. Introduction

With the development of human society, the industrialization process has been rapidly advanced. Along with the development of a large number of resources were utilized, a series of global crises such as resource shortage, environmental pollution and climate change have been triggered. Therefore, a new round of energy transformation led by large-scale development and utilization of clean energy is in full swing. Clean, low-carbon, safe and efficient are important features of the new round of energy transformation and it is an important way to deal with global environmental pollution and climate change. Electricity is a clean, efficient and convenient secondary energy source. Its role in energy transformation is increasingly important. Continuous improvement of electrification level is an important path to achieve the energy transformation. At the same time, the level of electrification is an important indicator of the level of modernization of a country or region. Due to the different conditions of different countries, the electrification development process has both commonalities and differences.

This paper compares the level of China's electrification with the global and 10 typical countries (including six developed countries that are US, UK, France, Germany, Japan, South Korea, and four BRICS countries that are Brazil, Russia, India, South Africa)¹, summarizes the development characteristics of global electrification level, analyzes the current situation of China's electrification level. In the end, we comprehensively consider the factors affecting the electrification process to judge the development trend of China's electrification process in the future.

2. Comparison of electrification level

¹ In this paper, the level of electrification refers to the share of electricity in the final energy consumption, which is calculated by the ‘Energy Balance’ of IEA. The analysis year is 1980-2016.
This section compares the overall level of electrification and the level of electrification in sub-sectors, including the four sectors of industry, transport resident, and commerce.

2.1. Comparison of overall electrification level

Affected by the continuous advancement of industrialization, China's electrification level has increased significantly, and surpassed the level global average and some developed countries. From 1980 to 2016, China's electrification level increased from 4.4% to 22.6%, an increase of 18.2 percentage points, the largest increase in typical countries, from 6.5 percentage points behind the global level to 3.8 percentage points over global level.

Compared with typical countries, China's electrification level was the lowest in 1980. Compared with the six developed countries, the gap was obvious. The gap with Japan was 14.7 percentage points, and the gap with Korea was 4.6 percentage points. There was also a gap with other BRICS countries. The gap with South Africa was 13.8 percentage points, and the gap with India was the smallest which was 0.1 percentage points. In 2016, China's electrification level has surpassed most typical countries. Among developed countries, China surpassed Germany, UK and US by 2.7, 2.2, and 1.0 percentage points, but still lower than Japan, France, and Korea by 5.7, 2.4 and 2.3 percentage points. Among the BRICS countries, China was only 1.0 percentage points lower than South Africa and has surpassed Russia, India and Brazil by 9.0, 5.9 and 3.8 percentage points respectively.

2.2. Comparison of sub-sector electrification level

The industrial electrification of typical countries has increased rapidly. The level of industrial electrification in China was at a medium-low level in typical countries, slightly higher than the global level and US. From 1980 to 2016, China's industrial electrification level increased from 9.2% to 28.6%, an increase of 19.5 percentage points, 1.5 and 2.7 percentage points higher than the global and US respectively. However, there was still a large gap between the countries with leading industrial electrification levels. Compared with Korea, South Africa, France, China was still 19.1, 10.5, and 8.9 percentage points behind them respectively.
The electrification level of transport in most typical countries fluctuated at a low level. The electrification level of China's transport was second only to Russia in typical countries. From 1980 to 2016, China's electrification level of transport increased from 1.0% to 3.3%, an increase of 2.3 percentage points, 4.2 percentage points lower than Russia. The electrification of transport in most countries was at a low level of fluctuations, fluctuating between 0% and 3%, mainly because the transportation industry was highly dependent on oil and difficult to be replaced by electricity. Among them, the electrification level of transport in Japan, Germany, South Africa and Korea declined.

The electrification level of commerce far exceeded other sectors. China's commercial electrification level has increased substantially, but still lagged behind other typical countries. From 1980 to 2016, China's commercial electrification level increased from 0.0% to 34.9%, an increase of 34.9 percentage points, achieving leap-forward development, but was still the last in typical countries. It is 1.4 percentage points lower Russia, and were 56.9 and 30.6 percentage points lower than leading countries of Brazil and Korea. The commercial electrification level of was much higher than other sectors, mainly due to the commercial energy structure is relatively simple and the requirements for energy quality are higher. As a clean, efficient and convenient final energy, electricity can meet the majority of commercial energy demand. It is worth mentioning that the commercial electrification level in Brazil has exceeded 90%, reaching 91.7%, far ahead of other countries.

The residential electrification level in all typical countries has continued to increase, and the residential electrification level of Chinese has increased significantly, but it was still lower than most typical countries. From 1980 to 2016, the residential electrification level of China increased from 0.4% to 22.3%, with an increase of 21.9 percentage points. It was only higher than Germany, India and Russia, and was 30.0 and 26.7 percentage points lower than the leading countries of Korea and US. Residential electrification level was mainly related to resource endowment, energy use habits and urbanization level. Japan and US have high level of urbanization, stronger electricity preference, and their electrification level were in leading positions, respectively 52.3%, 49.0%. Russia is rich in oil and gas resources. The
use of oil and gas preferences is stronger, so the level of electrification was much lower than other countries, which was only 12.1%.

Figure 5. Residential electrification levels in typical countries, 1980/2016.

3. Factors affecting the electrification process
Development of economy and society will boost the electrification level. The electrification level in countries with developed economies is generally higher than that in undeveloped countries. As an important basic resource to support economic growth, electricity is the “barometer and wind vane” for economic operations, and economic growth must bring about an increase in demand for electricity. For example, the advancement of industrialization process can boost the level of industrial electrification, the advancement of urbanization can boost the electricity consumption of residents and promote the electrification of resident.

Energy policy promotes the transformation of energy consumption structure into electrification. From the perspective of energy production, China vigorously promotes the development of non-fossil energy, and plans that non-fossil energy will account for 15% and 20% of primary energy in 2020 and 2030. Most non-fossil energy can only be converted into electricity for use. From the perspective of energy consumption, large-scale utilization of industrial electric boilers, electric kiln furnaces, electric vehicles, electric rail transit, and home electrification will greatly boost the electrification level.

Technological progress supports the transformation of energy consumption into electrification. The technology of renewable energy generation will be further matured, achieving flexible control and flexible scheduling, and generation cost will continue to decline. Distributed power supplies are built to suit local conditions and help clean energy consumption. UHV transmission, flexible AC/DC transmission, source-network-load interaction, intelligent control, energy storage will be fully applied to make sure the grid security stability, flexible operation level will be further improved. The utilization of advanced Internet technologies such as intelligent, big data and 5G will greatly enhance the power information sharing and flexible configuration capabilities.

Challenges such as environmental protection, climate change will force the electrification level to increase. As a clean, efficient and convenient secondary energy source, electricity can consume a large amount of clean energy on the power generation side. It has no pollution on the consumption side and is more efficient to use. Electrification is an important way to promote environmental protection and prevent climate change. And it will be an important hub for energy transformation [7-8].
Figure 6. The influence mechanism of electrification.

4. Judgment of future electrification level
Taking into account factors such as economic and social development, technological progress, and energy transformation, and under the support of clean and electrified energy policies, the development trend of China's electrification level will be judged.

China's electrification level will be accelerated. The electricity consumption of industrial electric boiler, advanced equipment manufacturing, electrified railway, electric vehicle, household electrification and smart home will be in massive use. It is estimated that by 2050, China's electrification level will reach around 50%, becoming the largest terminal energy source. The level in 2016 has more than doubled.

For the sub-sectors, the industrial electrification level will increase to more than 55%. The commercial and residential energy structure is relatively simple, the electrification process is the fastest, and the electrification level is both expected to exceed 70%. The electrification process in the transportation sector is the slowest, mainly due to that its dependence on oil consumption is relatively high. For example, aircraft, ships and other fuel consumption are difficult to be replaced by electricity. It is expected that the electrification level of the transport will only reach 20%-30% [9].

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