Comparison of the access level of new energy between domestic and foreign power grid

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Abstract. In the background of energy transformation, the world has witnessed the rapid development of new energy generation, with the proportion of capacity and electricity continuously increasing. However, different countries and regions have great differences in the access level of new energy. When a high proportion of new energy is connected to the system, it is neither scientific nor reasonable to reflect the development and absorption level of new energy only by such indicators as the proportion of new energy installed and the proportion of electricity generated. This paper analyzes the development status of new energy at home and abroad, and constructs the evaluation index system of the access level of new energy in power grid. Based on the evaluation index system, the access levels of new energy in different countries and regions are compared and analysed. At last, several key issues that need to be solved to achieve the goal of high proportion of new energy access in China are put forward.

1 Introduction

Building a green and low-carbon energy system is the essential requirement of the new energy security strategy of “Four Revolutions and One Cooperation”. In the past decade, with the continuous progress of energy transformation, all major countries and regions in the world have set development goals for energy transformation to increase the proportion of new energy. China, the United States, Germany, Denmark and Spain continue to expand the scale of new energy generation, and the proportion of new energy generation in total power generation has been increasing continuously.

When a high proportion of new energy is connected to the system, it is neither scientific nor reasonable to reflect the development and penetration level of new energy only by such indicators as the proportion of new energy installed and the proportion of electricity generated. At present, the research on the evaluation index system is not enough [1-6]. In [1], the economic evaluation model of grid-connected alternative energy is built to guide the planning and construction of the alternative energy. In [2], A detailed evaluation index system from four aspects is established. But it only considers the indexes including the proportion of new energy installed, the proportion of electricity generated and the utilization rate of new energy. In [3], it proposes an integrated model to study which renewable energy is the most suitable in Taiwan. The results are used to guide the development of renewable energy in the future.

Considering the problems above, this paper proposes the evaluation index system to evaluate the access level of new energy objectively and generally. New energy in this paper includes wind and solar power only.

2 Development status of new energy at home and abroad

In the background of energy transformation, the global installed capacity of new energy generation is growing rapidly. As shown in Fig.1, from 2010 to 2019, the average annual growth rate of global new energy capacity is 20.2%. By the end of 2019, the global installed capacity of new energy has reached 1.25 billion kW, accounting for 16.8% of the total installed capacity in 2019, up from 4.6% in 2010.

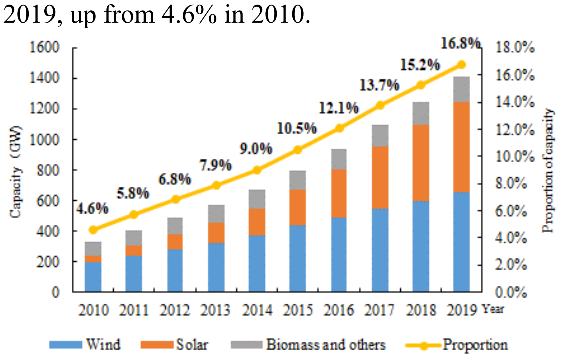

Fig. 1. Global Installed Capacity and Proportion of New Energy Generation from 2010 to 2019.

The share of the world’s electricity generated by new energy continues to rise. As shown in Fig.2, from 2010 to 2019, the average annual growth rate of the electricity of the world’s new energy is 20.5%. The average annual growth rate of the electricity of wind and solar power is

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16.3% and 40.1%, respectively. In 2019, the global generating electricity of new energy is 2073.7 billion kW·h, which increases from 1.9% in 2010 to 8.1% in 2019.

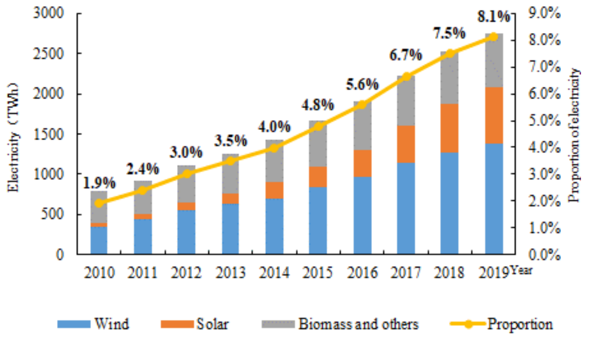

Fig. 2. New Energy Generating Electricity and the Share in the World from 2010 to 2019.

In Table 1, it shows the changes in the proportion of new energy capacity and electricity generation in typical countries and regions from 2010 to 2019.

Table 1. Changes in the proportion of new energy installations and electricity generation in typical countries and regions.

Region/Country	Term	2010	2019
Global	Proportion of capacity	4.6%	16.8%
	Proportion of electricity	1.9%	8.1%
EU	Proportion of capacity	13.1%	31.3%
	Proportion of electricity	5.6%	17.8%
US	Proportion of capacity	3.8%	14.7%
	Proportion of electricity	2.7%	10.3%
Germany	Proportion of capacity	27.5%	51%
	Proportion of electricity	8.8%	28.3%
Denmark	Proportion of capacity	32.3%	47.7%
	Proportion of electricity	21.3%	61.6%
Spain	Proportion of capacity	23.3%	33.5%
	Proportion of electricity	18%	25.8%
China	Proportion of capacity	3.1%	21%
	Proportion of electricity	1.2%	8.6%

The development of new energy shows a leading trend among big countries. As shown in Fig.3, by the end of 2019, China, the United States, Germany, India and Japan have a combined installed capacity of 870 million kW of new energy, accounting for 69.6 percent of the world's total installed capacity of new energy.

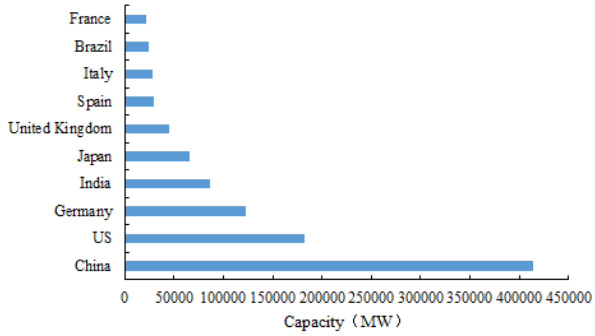

Fig. 3. The World's Top 10 Countries in New Energy Installed Capacity in 2019.

3 Evaluation index system for the access level of new energy

With the continuous expansion of the installed capacity of new energy and the continuous increase of the proportion of electricity generation, the role of new energy generation in the adjustment of energy structure has become prominent. In order to better reflect a country or region's new energy development degree and the green level of electricity, this paper, from the dimensions of installed capacity and electricity generation, proposes an evaluation index system. And four evaluation indexes are defined, including new energy penetration rate, new energy access rate, green level of power supply and green level of electricity generation. The four evaluation indexes are shown in Table 2.

Table 2. New Energy Access Level Evaluation Index System.

No.	Evaluation Index	Formulation
1	New energy penetration rate	Ratio of new energy generating electricity to total system electricity consumption
2	New energy access rate	Ratio of installed new energy capacity to total installed power generation capacity
3	Green level of power supply	Ratio of new energy installed capacity to thermal power installed capacity
4	Green level of electricity generation	Ratio of new energy generating electricity to thermal power generating electricity

For the index of new energy penetration rate, it could be formulated as follows.

$$I_1 = \frac{E_{new}}{D_{all}} \times 100 \quad (1)$$

In (1), E_{new} is the new energy generating electricity and D_{all} is the total system electricity consumption. For the index of new energy penetration rate, if the index is high, it shows that the share of new energy generating electricity in terminal power consumption is high.

For the index of new energy access rate, it could be formulated as follows.

$$I_2 = \frac{N_{new}}{N_{all}} \times 100 \qquad (2)$$

In (2), N_{new} is the installed capacity of new energy and N_{all} is the total installed capacity in the system. For the index of new energy access rate, if the index is high, it shows that the proportion of new energy installed capacity in the system is high.

For the index of green level of power supply, it could be formulated as follows.

$$I_3 = \frac{N_{new}}{N_{thermal}} \qquad (3)$$

In (3), $N_{thermal}$ is installed capacity of thermal units. For the index of green level of power supply, if the index is higher, it shows that the degree that the installed capacity of new energy in the system exceeds that of thermal power is much larger, reflecting the higher degree of the green transformation of power structure.

For the index of green level of electricity generation, it could be formulated as follows.

$$I_4 = \frac{E_{new}}{E_{thermal}} \qquad (4)$$

In (4), $E_{thermal}$ is the generating electricity of thermal units. For the index of green level of electricity generation, if the index is higher, it shows that the degree that the power generation of new energy in the system exceeds that of thermal power generation is much larger, which reflects that the degree of the green transformation of the power generation structure of the system and the low-carbon generation level of the system are higher.

4 Case study

4.1 Comparative analysis of new energy access level at home and abroad

Based on the evaluation index system of new energy access level of power grid, a comparative analysis of new energy access level between different countries and regions is carried out. In the comparative analysis, the comparability of installed capacity, electricity demand and power grid scale is comprehensively considered. Therefore, one comparative analysis is conducted between China and countries with similar scale power systems, such as the EU and the US. The other comparative analysis is carried out between typical Chinese provinces and countries with similar scale power systems, such as Germany, Denmark and Spain.

4.1.1 Comparative analysis of new energy access levels in China, the EU and the US

The following table shows the comparison results of new energy access levels for China, the EU and the US in 2019.

Table 3. Comparison results of new energy access level for China, the EU and the US in 2019.

Country	I_1	I_2	I_3	I_4
China	8.7%	20.6%	0.35	0.12
EU	19.2%	31.3%	0.82	0.43
US	11.4%	14.7%	0.22	0.17

As shown in Table 3, some conclusions could be obtained.

1) The EU has the highest access level of new energy and is in the world's leading positon. The EU is ahead of China and the US in all the four evaluation indexes.

2) On the whole, China's access level of new energy is almost the same as that of the United States, which is at the advanced level in the world. In the indexes of new energy access rate and green level of power supply, China is higher than the US. However, in the other two indexes, China is lower than the US.

It could be seen that although the installed capacity of new energy in the United States is lower than that of China, the United States has good natural resources and the electricity of new energy is high. While promoting the rapid development of new energy, China has yet to raise the electricity level of new energy. What's more, affected by the power structure, China's thermal power generation is still in the main position, and the electricity of thermal power is high. As a result, the green level of electricity generation in China is low.

4.1.2 Comparative analysis of new energy access levels between typical Chinese provinces, Germany, Denmark and Spain

The following table shows the comparison results of new energy access levels for typical Chinese provinces, Germany, Denmark and Spain in 2019.

Table 4. Comparison results of new energy access levels for typical Chinese provinces, Germany, Denmark and Spain in 2019.

Country	I_1	I_2	I_3	I_4
Germany	32.5%	51%	1.46	0.57
Denmark	54.7%	47.7%	1.26	3.62
Spain	28.1%	33.5%	0.83	0.61
Qinghai	31.3%	50%	4.03	2.15
Gansu	26.9%	42.2%	1.06	0.42
Xinjiang	19%	31.3%	0.51	0.20
Ningxia	27.8%	38.4%	0.63	0.22

As shown in Table 4, some conclusions could be obtained.

1) Denmark has the highest access level of new energy on the whole, while Germany and Qinghai have the same access level of new energy, both leading the world. In the indexes of new energy penetration rate and green level of electricity generation, Denmark leads by a large margin. However, in the index of green level of power supply, Qinghai is ahead of Denmark. This is mainly because in the power supply structure of Qinghai, there are many installed hydropower plants, while thermal power plants only play a role of supplementary power, so the overall green level of power supply is high.

2) The access level of new energy in Gansu and Ningxia is almost the same as that of Spain, which is at the advanced level in the world. The installed capacity of new energy in Xinjiang develops rapidly, but the electricity generation of new energy grows slowly, and the access level of new energy is low. In all the four evaluation indexes, Xinjiang is lower than Germany, Denmark, Spain and other typical provinces of China.

4.2 Key issues that need to be solved to realize high access level of new energy in China

First, we need to take multiple measures to improve the utilization of new energy and shift its development from one based on scale and speed to one based on quality and efficiency. To realize the goal of energy transformation, China should not only pay attention to the continuous increase of the scale of new energy, but also to the continuous improvement of the utilization level of new energy. To improve the utilization level of new energy, we need to take multiple measures on the power generation side, the power grid side and the load side.

Second, we should scientifically position the role of different types of power sources, coordinate the development of new energy and the scale of flexible resource allocation, formulate the rational utilization rate of new energy, and realize the overall optimal power generation efficiency of the system. There are great differences in power grid structure, power supply structure and load characteristics in different regions in China. In advancing the development of new energy, the rational utilization rate of new energy should be determined based on the specific situation of each region. And we should develop and build flexible resources in an orderly manner, and accelerate the transformation and upgrading of coal power plants.

Third, we need to give full play to the role of the electricity market to promote the development and penetration of new energy. In the electricity market, market players compete with the marginal cost. New energy has an absolute advantage in market competition due to its low marginal cost of power generation. China should accelerate the construction of spot market. Through the connection of multi-time scale and multi-market space, new energy consumption can be promoted to the greatest extent.

5 Conclusion

According to the comparison of evaluation indexes of new energy access level at home and abroad, China's new energy access level as a whole is at the advanced level in the world. However, there is still room for further improvement in the penetration rate of new energy and the green level of electricity generation. With the advent of wind-solar power parity era, China's new energy development scale will be further increased. In order to scientifically reflect the development and penetration level of new energy, this paper proposes the evaluation index system to evaluate the access level of new energy objectively and generally.

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