Research on the early warning analysis of new energy accommodation in China.

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Abstract. The assessment of new energy consumption will help to guide the development and utilization of new energy and promote the sustainable and healthy development of new energy generation industry in China. The paper analyses the development of new energy installations and operation in China. Considering the new energy abandoning rate, the annual utilization hours, and regional new energy consumption proportion, an early warning analysis model of the new energy accommodation is established. Based on the analysis results of China's new energy generation development, new energy accommodation early warning analysis in China is proposed. The results show that 1) early warning results for wind power accommodation in shandong, shanxi and ningxia is higher in 2012-2017. The early warning indexes in jilin, heilongjiang, gansu and xinjiang are is low. 2) In 2014-2017, the overall situation of solar power accommodation in qinghai and ningxia is better than that of gansu and xinjiang. And the situation in 2014-2016 are better than 2016-2017.

1. Introduction

Vigorously developing new energy is an important measure to realize China's energy transformation. Under the guidance of national energy strategy and policy, new energy is developing rapidly in China [1]. By the end of 2017, new energy generation capacity in China is 293.93 million kilowatts, accounting for 17 percent of the total power supply capacity. Moreover, there are 20 provinces in China where the new energy installed capacity account for more than 10 percent of the total capacity. However, with the rapid scale development of new energy generation in China, the problem of insufficiency is becoming more and more prominent. In 2016, the total amount of abandoned wind power in China reached 49.7 billion KWH, and the amount of abandoned solar power reached 70.42 billion KWH. The direct economic loss was 28.5 billion yuan. The bottleneck of the development of new energy industry transforms to the restricts of power system's capacity and operation mechanism from the constraint of technological equipment and development and construction capacity[2].Therefore, in order to promote the sustained and healthy development of new energy power generation industry in China, it is necessary to establish a comprehensive scientific and accurate the new energy accommodation early warning analysis system, which can scientifically evaluate the operation and accommodation level of new energy power. The results can actively guide the new energy development and utilization of accurate work [3, 4].

According to the new energy development goals and objectives of national and local governments, an early warning analysis model for evaluating new energy power accommodation level is established in this paper, which considers the proportion of abandoned power, annual power utilization hours and power accommodation proportion. On this basis, the wind and solar power accommodation level in the major areas are analyzed. And the focus work to promote the development of new energy industry in China are expounded in this paper.

2. Overview of new energy generation development in China

By the end of 2017, the total installed capacity of new energy generation capacity in China is 293.93 million kilowatts, accounting for 17% of the total installed capacity of the country. Among them, the total installed capacity of wind power is 163.67 million kilowatts, and the total installed capacity of solar power generation is 13.25 million kw. New energy installations are concentrated in the "three north" regions." The cumulative installed capacity of wind power in "three north" regions is 121.73 million kilowatts, accounted for 74% of the national wind power installed capacity. The wind power installed capacity in Inner Mongolia is more than 20 million kw, xinjiang, gansu, hebei, shandong, are more than 10 million kilowatts. The total installed capacity of solar power generation in the "three north" region is 7556 million kw, accounting for 58 percent of the total installed capacity of solar power generation in China. The solar power generation capacity in Shandong exceeds 10 million kw, xinjiang, jiangsu, anhui, hebei, zhejiang are over 8 million kilowatts. In 2017, the country's new energy generation capacity will be 6809 gigawatts, accounting for 52% of the new installed capacity. The new installed capacity is mainly concentrated in the eastern and central regions.

In China, the power grid is not coordinated with the power plan, the local accommodation capacity is limited, interregional transmission channel and peaking capacity are inadequate, and the market mechanism is deficient. Therefore, the new energy accommodation contradiction in "three north" regions is conspicuous. The abandoned new energy power in Xinjiang and Gansu accounts 66% of the total abandoned new energy power. In 2017, the loss of power caused by wind power restriction in China was 41.9 billion kW•h, the wind abandoning rate was 12%, which was better than the situation in 2016 [4].In 2017, the wind power abandoned rate in Gansu (wind power abandoned rate is 33%, abandoned power is9.2 billion KWH), Xinjiang(wind power abandoned rate is 29%, abandoned power is13.3 billion KWH), Jilin(wind power abandoned rate is 21%, abandoned power is 2.3 billion KWH),Inner Mongolia(wind power abandoned rate is 14%, abandoned power is 1.8 billion KWH) and Heilongjiang(wind power abandoned rate is 14%, abandoned power is 1.8 billion KWH) are more than 10%. In 2017, the loss of electricity caused by the abandoned solar power was about 6.7 billion kW•h, and the solar power abandoned rate was 6.3%. The abandoned rate in northwest region are alleviate. The amount of abandoned solar power dropped by 6% compared with the same period in last year. In gansu and xinjiang, the amount of abandoned solar power decreased by 28% and 3% respectively, and the abandoned rate decreased by 9.9% and 8.6 % respectively.

3. Early warning analysis of new energy accommodation in China.

3.1. Early warning analysis indicators for new energy accommodation evaluation

Early warning analysis indicators for new energy accommodation evaluation reflect the situation of wind power and solar power generation in various regions. In order to scientifically and quantitatively evaluate the new energy accommodation situation, an early warning analysis model for evaluating new energy power accommodation level is established in this paper, which considers the proportion of abandoned power, annual power utilization hours and new energy power accommodation proportion. The early warning analysis indicators and concepts for new energy accommodation evaluation are shown as below:

The proportion of abandoned power: The ratio of abandoned new energy generation to the total new energy generation, which reflects the abandoning degree of new energy generation in different regions [1].

The annual power utilization hours: The annual operating hours of the average power generation capacity under full operating conditions, namely the ratio of annual power generation to average installed capacity. This indicator reflects the utilization rate of new energy generation equipment in different regions. [1].

New energy power accommodation proportion: The proportion of local new energy consumption accounts for the electricity consumption in the whole society, which reflects new energy accommodation capacity in this region.

3.2. Early warning analysis model for evaluating new energy power accommodation
In this paper, the interpolation method is used to calculate the new energy generation accommodation index. The calculation formula of interpolation method is shown as follows:

$$\mathrm{Re}\,new_p = \frac{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}\left(Cp - BP_{Lo}\right) + \mathrm{Re}\,new_{Lo} \tag{1}$$

$$\mathrm{Re}\,new_p = \mathrm{Re}\,new_{Hi} - \frac{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}{BP_{Hi} - BP_{Lo}}\left(Cp - BP_{Lo}\right) \tag{2}$$

In the formula, $\mathrm{Re}\,new_p$ is the early warning index of new energy accommodation in each region, which reflects the warning degree of the new energy generation. $\mathrm{Re}\,new_{Hi}$ is the early warning index of new energy accommodation corresponding to high critical value Cp. $\mathrm{Re}\,new_{Lo}$ is the early warning index of new energy accommodation corresponding to low critical value Cp. BP_{Hi} is the low critical value closed to Cp.

In this paper, the new energy accommodation early warning is calculated by interpolation, and the early warning index of new energy accommodation is obtained by weighted average. Based on the expert consultation and research method, the weight of the proportion of abandoned power, annual power utilization hours and power accommodation proportion is 0.5, 0.25 and 0.25 respectively. The warning range of the new energy generation for energy generation is divided into three levels (0-50, 50-75, 75-100), respectively, and corresponding to the three warning levels of red, orange and green respectively. The critical value and grading standard of early warning indicators for new energy accommodation are determined according to "the wind power investment monitoring and early warning index calculation method" and "the photovoltaic market environment monitoring and evaluation method and standard" and other relevant provisions [5, 6], shown as in table 1 and 2:

4. Results of early warning for new energy accommodation in China.

4.1. Results of early warning for wind power accommodation in China.
On the whole, early warning results for wind power accommodation in shandong, shanxi and ningxia is higher in 2012-2017. The early warning indexes in jilin, heilongjiang, gansu and xinjiang are is low.

From the provincial perspective, early warning results of jilin region has been red alert range. In 2012, 2015 and 2016, the proportion of abandoned wind power in jilin was higher than 30%, and the annual utilization hours were around 1400 hours, which led to the early warning indexes of wind power accommodation are lower than the other years. In 2017, the state grid company takes more attentions on new power accommodation and put forward different measures simultaneously. Therefore, the proportion of abandoned wind power in jilin reduced by10%, the annual utilization hours reached to 1721, and the early warning indexes for wind power accommodation are improved significantly.

Table 1. Wind power accommodation early warning analysis index classification critical value.

Early warning index	Resource area	Proportion of abandoned wind power	Annual power utilization hours	Wind power accommodation proportion.
0～35	I	0～10%	2200～2400	0%～5%
	II		1400～2000	
	III		1400～1800	
	IV		1100～1500	
35～70	I	10%～20%	2200～2400	5%～10%
	II		2000～2200	
	III		1800～2000	
	IV		1500～1800	
70～100	I	20%～40%	2200～2400	10%～30%
	II		2200～2600	
	III		2000～2400	
	IV		1800～2200	

Table 2. Solar power accommodation early warning analysis index classification critical value.

Early warning index	Resource area	Proportion of abandoned solar power	Annual power utilization hours
0～35	0～5%	800～1200	0%～5%
35～70	5%～15%	1200～1500	5%～10%
70～100	15%～40%	1500～1700	10%～30%

In gansu province, except for 2013, early warning indexes for wind power accommodation has been in the red alert range. From 2015 to 2017, the proportion of abandoned wind power in gansu is as high as 40%, and the annual utilization hours is only about 1,100 hours, leading to the lower than other years of wind power accommodation in gansu province in 2015-2017. In 2017, the state grid company takes more attentions on new power accommodation and put forward different measures simultaneously. The annual utilization hours of wind power in gansu reached to 1500, but the proportion of abandoned wind power is as high as 33%, the early warning indexes for wind power accommodation is only 20, belongs to the red alert interval.

From 2015 to 2017, the early warning indexes for wind power accommodation in xinjiang has decreased significantly, which become a red alert from the green and orange alerts in 2012-2014. This is mainly due to the serious wind abandoning situation in xinjiang in 2015-2017, with the proportion of wind abandoning up to 30%, and the annual utilization hours are significantly lower than the historical period.

Table 3. Wind power accommodation index in China

	2012	2013	2014	2015	2016	2017
Jibei	56.84	52.29	52.71	53.26	68.13	78.88
Shanxi	69.46	85.35	75.30	70.92	70.61	77.88
Shandong	73.98	74.40	72.27	74.16	74.30	72.64
Liaoning	54.19	69.57	67.57	55.91	62.88	80.78
Jilin	19.82	39.00	41.22	23.56	23.01	41.80
Heilongjiang	53.99	59.90	54.97	31.68	54.44	63.54
Mengdong	21.93	55.45	54.50	50.02	43.13	55.73
Shanxi	73.05	65.25	72.78	74.33	64.83	68.39
Gansu	31.58	54.68	46.64	5.00	1.01	20.13
Ningxia	73.64	80.47	79.65	52.11	51.72	67.39
Xinjiang	82.52	75.13	59.12	34.19	32.89	42.43

4.2. Results of solar power accommodation index in China.

As a whole, in 2014-2017, the overall situation of solar power accommodation in qinghai and ningxia is better than that of gansu and xinjiang. And the situation in 2014-2016 are better than 2016-2017.

In terms of provinces, the solar energy power accommodation situation in 2014-2016 were poor, and the early warning results were all red. In 2017, the state grid company takes more attentions on new power accommodation and put forward different measures simultaneously. The proportion of abandoned solar power in gansu fell by 10%, the annual utilization hours increased by 12%. The solar power accommodation early warning indes increased to 45, become orange early warning result.

In 2015-2016, the situation of abandoned light in xinjiang was serious, and the proportion of abandoned solar power was higher than 25%. The results of solar power accommodation were red. In 2017, the state grid company takes more attentions on new power accommodation and put forward different measures simultaneously. The proportion of abandoned solar power and the annual utilization hours in xinjiang were obviously improved. The proportion of abandoned solar power fell by 9%, the annual utilization hours increased by 28%, the early warning result became orange.

Table 4. Solar power accommodation index in China

	2014	2015	2016	2017
Gansu	32.12	39.94	36.69	45.43
Qinghai	76.22	74.60	64.84	62.79
Xinjiang	68.03	31.19	25.40	39.16
Ningxia	75.67	56.69	51.63	54.78

5. Conclusion

In recent years, with the continuous rapid development of new energy generation in China, the problems of new energy accommodation have become increasingly prominent, resulting in huge national economic losses. In order to promote the sustainable and healthy development of new energy power generation industry in China, this paper build an early warning analysis model for evaluating new energy power accommodation level, which considers the proportion of abandoned power, annual power utilization hours and power accommodation proportion. On this basis, the wind and solar power accommodation level in the major areas from 2012-2014 are analyzed. The results show that: 1) early warning results for wind power accommodation in shandong, shanxi and ningxia is higher in 2012-2017. The early warning indexes in jilin, heilongjiang, gansu and xinjiang are is low. 2) in 2014-2017, the overall situation of solar power accommodation in qinghai and ningxia is better than that of gansu and xinjiang. And the situation in 2014-2016 are better than 2016-2017.

New energy accommodation is a system engineering, which needs government departments, power grid enterprises, power companies and users work together. In order to promote the new energy accommodation, the work should be focused on four aspects: one is to strengthen the top-level design, unified plann and balance at the national level [7,8]. Second, we will promote the construction of market mechanisms, accelerate the construction of a unified national power market, and allow the market to play a decisive role in the allocation of resources and break down barriers between provinces through market means [9]. Thirdly, strengthen uhv interregional transmission project planning and construction, and give full play to their roles as the good optimal allocation of grid resource platform [10].

Acknowledgments

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