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Comprehensive Evaluation of Grid Green Development with Ecosystem from the Perspective of Energy Industry Chain

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Abstract

In the context of the "14th Five-Year Plan" and the "Dual Carbon Goals", the green development of power grid not only affects the transformation of the energy power system, but also profoundly affects the formation of the green production and lifestyle of the economy and society. Therefore, it is urgent to study the coupling relationship between green development of power grid and ecosystem to adapt to the new situation. This paper establishes the comprehensive evaluation of grid green development with ecosystem from the perspective of energy industry chain and then quantitatively evaluate the level of green development.

Keywords: green development of power grid, ecosystem, comprehensive evaluation

1. Introduction

The 14th Five-Year Plan is a key period for China's high-quality economic and social development and high-level protection of the ecological environment. With the "Dual Carbon Goals", the construction of a new power system with a gradual increase in the proportion of new energy has become a trend, and the power grid will become a core hub for the production and consumption of clean energy, becoming an important cornerstone for leading the energy transition and promoting the low-carbon development of production and lifestyle. With the continuous upgrading of the power grid function, the influence of green development of power grid on upstream and downstream industrial also changes. From the perspective of the energy industry chain, the green development of power grid not only affects the transformation of the energy power system, but also profoundly affects the formation of the green production and lifestyle of the economy and society. Therefore, it is urgent to evaluate the state of green development of power grid and ecosystem under the new situation, so as to provide reference for national decision-making.

At present, the research on the green development of power grid focuses on the development of power grid itself. Wu Kecheng et al.put forward the green development-oriented grid enterprise environmental protection management system optimization recommendations based on the background of domestic ecological civilization system reform and system construction[1]; Liu Wanxun et al. established multi-level grid development impact index system based on security, economy, coordination, intelligence and green, and built a multi-level fuzzy comprehensive evaluation model

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of grid development level [2]; Wang Hua set up evaluation indicators of energy conservation and environmental protection from the aspects of the grid loss, operating energy consumption, grid environmental protection level [3]; Wang Wei developed the index system of green power grid from five aspects: safety and reliability, green level, economy, intelligence level and efficiency level [4].

In general, research about the green development of power grid is not only limited to the environmental protection of the power grid itself, but also including the positive role of the power grid coordinated upstream and downstream in promoting energy transformation. This paper constructs the index system of green development of power grid from the angle of energy industry chain, establishes the index system of ecosystem evaluation based on the theory of pressure-state-response so as to assess their level of green development, and then synthetically evaluates the development level of the two.

2. The coupling mechanism of green development power grid and ecosystem

From the perspective of energy industry chain, the coupling mechanism of grid development and ecological environment is mainly reflected in three aspects[5-8]. The first is that the power grid promotes the development of clean energy in coordination with the upstream, and realizes the balance of power supply and demand in energy-rich areas and load-concentrated areas by promoting the cross-provincial and cross-regional transmission of clean energy. The second is the impact of the whole life cycle of power grid construction, operation and decommissioning on the ecological environment, such as electromagnetic noise pollution, waste pollution, waste water discharge, greenhouse gas emissions. The third is to guide the downstream of the power grid to promote clean energy consumption, fully tap the potential of power substitution at the user side, increase the proportion of terminal power, and realize the optimal allocation of power resources.

3. Coupling evaluation index system

3.1. Green development evaluation index system of power grid

The green development of power grid establishes evaluation indicators from three dimensions: coordinating upstream green development, realizing its own green development, and promoting downstream green development, as shown in Table 1.

Table 1 Evaluation index system of green development of power grid

Level-1 indicator	Code	Secondary indicator
Power grid coordinated upstream green development (A1)	B1	Clean energy generation as a percentage of total generation (%)
	B2	New energy efficiency (%)
	B3	Cross-regional line transmission capacity (100 MW)
	B4	Scale of grid-side energy storage (10,000 Kw)
	B5	Environmental assessment rate for construction projects (%)
	B6	Environmental acceptance rate of completed projects (%)
Green development of power grid (A2)	B7	Sulphur hexafluoride recovery (%)
	B8	Comprehensive line loss rate (%)
	B9	Annual monitoring coverage of electromagnetic noise in substations (%)
	B10	General waste disposal rate (%)
	B11	Disposal rate of oil of Waste transformer (%)
	B12	Disposal rate of waste lead-acid batteries (%)
	B13	Replacement of electrical energy (100 million kWh)

Power grid coordinated downstream green development (A3)	B14	Electricity as a percentage of terminal energy consumption (%)
	B15	New electric vehicle charging piles (10, 000)

3.2. Ecosystem assessment indicator system

In this study, the influence of power system on ecological environment is fully considered, and the basic principle of pressure-state-response model is used to construct the ecosystem evaluation index system, as shown in Table 2. Among them, the pressure index represents the impact of human economic and social activities on the environment. In the process of power production, transportation and consumption, it mainly involves the disturbance of atmospheric pollutants, greenhouse gases and solid waste emissions to the ecological environment. The state index characterizes the environmental state and the environmental change in a specific time period. The emission of air pollutants from power industry and noise pollution from power construction projects are considered. The response indicators mainly reflect how society and individuals act to mitigate, prevent, restore and prevent the negative impact of human activities on the environment, mainly considering the waste disposal rate, pollution control investment and so on.

Table 2 Ecosystem assessment indicator system

Level-1 indicator	Code	Level-3 indicator
Ecological environmental pressure (A1)	B1	Per capita CO2 emissions (ton/10, 000 people)
	B2	Per capita SO2 emissions (ton/10, 000 people)
	B3	Per capita NOx emissions (ton/10, 000 people)
	B4	Per capita smoke (dust) emissions (ton/10, 000)
	B5	Industrial solid waste generation per capita (10, 000 tons/10, 000 people)
State of the ecological environment (A2)	B6	Annual average CO2 concentration (ppm)
	B7	Annual average SO2 concentration (ug/m3)
	B8	Annual average NO2 concentration (ug/m3)
	B9	Annual average PM2.5 concentration (ug/m3)
	B10	Regional acoustic environment monitoring compliance rate (%)
Ecological environmental response (A3)	B11	Disposal of general industrial solid waste (10, 000 tons/day)
	B12	Industrial hazardous waste disposal (tons/day)
	B13	Investment in industrial pollution control (100 million yuan)

4. Research methods

4.1. Data standardization

In order to reflect the future development trend of the green development of power grid, the target value proposed by the future energy development strategy or the index value predicted by the trend extrapolation method is used as the reference value of each index. The indicator data closer to the reference value of each indicator is better, and the standardization method is as follows:

$$X_{ij}=\begin{cases}1-\dfrac{q_j-x_{ij}}{\max\left(q_j-\min_{1\le i\le n}\left(x_{ij}\right),\max_{1\le i\le n}\left(x_{ij}\right)-q_j\right)}, & x_{ij}<q_j\\ 1-\dfrac{x_{ij}-q_j}{\max\left(q_j-\min_{1\le i\le n}\left(x_{ij}\right),\max_{1\le i\le n}\left(x_{ij}\right)-q_j\right)}, & x_{ij}>q_j\\ 1 & ,x_{ij}=q_j\end{cases} \tag{1}$$

X_{ij} refers to the normalized value of the *j-th* indicator in the *i-th* evaluated year; q_j refers to the ideal value of the *j-th* indicator; and x_{ij} refers to the value of the *j-th* indicator in the *i-th* evaluated year.

For the ecological environment system, because the reference value cannot be specifically determined, the range method is used for standardization. The calculation formula is as follows:

Positive indicators: $$Y_{ij}=\frac{y_{ij}-\min(y_j)}{\max(y_j)-\min(y_j)} \tag{2}$$

Negative indicators: $$Y_{ij}=\frac{\max(y_j)-y_{ij}}{\max(y_j)-\min(y_j)} \tag{3}$$

y_{ij} is the original value of the *j-th* indicator in the *i* year; is the standard value after the treatment of the of the *j-th* indicator in the *i-th* year; and max (y_j) and min (y_j) is the maximum and minimum value of the *j-th* indicator.

4.2. Comprehensive evaluation function

In order to avoid the shortage of subjective judgment, the entropy weight method is used to determine the weight. The evaluation function of green development of power grid and ecosystem is as follows:

$$P(X)=\sum_{j=1}^{n}w_jX_{ij} \tag{4}$$

$$E(Y)=\sum_{j=1}^{n}w_jY_{ij} \tag{5}$$

$P(X)$ For the grid green development index, it reflects the comprehensive development level of the grid green development subsystem in the *i-th* year; *E(Y)* is the ecological environment index, which reflects the comprehensive development level of the ecological environment subsystem in the *i-th* year; w_j is the weight of the first indicator; and w_j and Y_{ij} respectively represent the standardized values of the *j-th* indicator of green development of power grid and ecological environment in the *i-th* year.

5. Evaluation results

5.1. Evaluation results of green development of power grid

Since the "Eleventh Five-Year Plan", the overall level of green development of power grid, the green development level of the power grid coordinated with upstream and downstream and the power grid itself have increased year by year. Among them, the comprehensive evaluation level of the green development of power grid itself is the highest and relatively stable, indicating that the current environmental protection level of power grid construction projects has reached a high level, and under the condition of a certain technical level, there is little room for future improvement. The comprehensive evaluation level of the power grid coordinated with upstream and downstream is relatively low, but in recent years, the growth rate is relatively fast. With the promotion of the "Dual Carbon Goals", the level of the power grid coordinated upstream and downstream green development will be further improved. Specifically as shown in Figure 1.

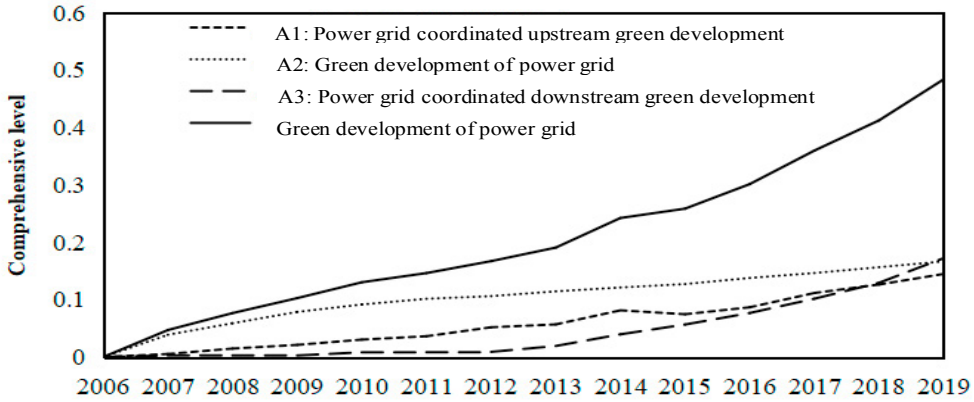

Fig. 1. Comprehensive evaluation level of green development of power grid.

5.2. Evaluation results of ecological environment system

Overall, the overall level of China's ecological environment has gradually improved, as shown in Figure 2. Among them, the overall pressure on the ecological environment has shown a downward trend, the state of the ecological environment has shown an upward trend in fluctuations, and the level of response to the ecological environment has increased rapidly, indicating that since the "Eleventh Five-Year Plan" period, the state has continuously increased its attention to the protection of the ecological environment, continuously strengthened its policies, gradually reduced the pressure on the ecological environment, and continuously improved the state of the ecological environment.

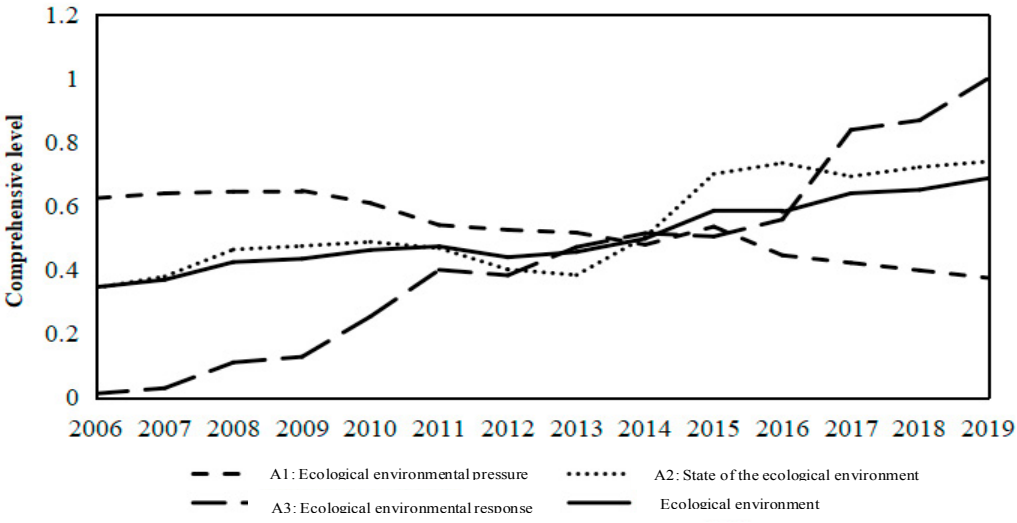

Fig. 2. Comprehensive assessment level of ecosystem.

6. Conclusions and recommendations

On the whole, in the process of promoting the green development of power grid in the future, the potential of the power grid coordinated upstream and downstream to promote the green development of power grid is large, and it should be taken as a priority. The development space of the power grid itself is relatively small, just keep it at the current level. Therefore, in practice, on the one hand, efforts should be made to improve the efficiency of cross-regional resource allocation and promote the consumption and utilization of new energy. On the other hand, efforts should be made to promote the construction of charging facilities and strengthen the substitution of electric energy.

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References

[1] Wu Kecheng, Zhao Dan.(2020) “Research on Environmental Protection Management System for Green Development Oriented Grid Enterprise. ” *Value Engineering*, **39 (20)**: 12-13.

[2] Liu Wanxun, Yu Linlin, Zhang Lihua, Yuan Peng, Wang Yang, Zhao Rui. (2020) “Assessment of grid development level based on AHP and multi-level fuzzy comprehensive evaluation.” *Wisdom Power*, **48 (05)**: 80-85.

[3] Wang Hua.(2019) “Comprehensive Evaluation of Energy Conservation and Environmental Protection for Huizhou Power Grid Based on Analytic Hierarchy Process.”*Guangdong University of Technology*.

[4] Wang Wei. (2015) “Theoretical and Empirical Research on Green Power Grid Development.”*North China Electric Power University*.

[5] Wang Zhaoquan.(2015) “Study on Environmental Impact Assessment and Risk Prevention of UHV Power Network Planning.” *North China Electric Power University*.

[6] Bai Jianguo.(2012) “Research on Sustainability Evaluation Model and Application of Power Grid Construction Project.” *North China Electric University*.

[7] Song Zongyun. (2018) “Study on power demand side management optimization under the background of air pollution control.” *North China Electric Power University* .

[8] Zheng Xinye, Wu You. (2018) “Price Mechanism Innovation for Green Development of Energy System.” *Price Theory and Practice*,**(4)**: 12-16.