Research on the implied carbon measurement and structural decomposition technology of power grid engineering based on structural analysis method

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Abstract: At present, with the development of "double-carbon", it has an important impact on the investment form of the power grid, and the emerging investment objects continue to expand, and the new investment management mode is constantly highlighted. In this context, in-depth research is carried out on the total factor carbon measurement of new power system construction projects, and the total factor measurement framework system and technical method are put forward, which is conducive to improving the efficiency and efficiency level of investment control of power grid enterprises. Therefore, this paper puts forward the implicit carbon measurement and structure decomposition technology of power grid engineering based on structural analysis method, which provides support and reference for project type division and scientific decision-making under the new situation of power grid enterprises.

1. Introduction

In September 2020, China proposed the goal of achieving a carbon peak by 2030 and achieving carbon neutrality by 2060. In March 2021, carbon peak and carbon neutrality were written into the 14th Five-Year Plan and the Outline of Long-term 2035 Goals to promote comprehensive green transformation of economic and social development, establish an economic system for green and low-carbon energy development, and take a path of high-quality development that gives priority to ecology and green and low-carbon. State Grid Co., Ltd. has issued an action plan of "Carbon peak, carbon neutral" to continuously promote energy transformation, accelerate the construction of a clean, low-carbon, safe and efficient energy system, and continue to promote carbon emission reduction. Current with the development of "double carbon" important influence on power grid investment forms, emerging investment object, new investment management mode, the new development of the power grid management target and power grid investment news need to deepen matching synergy, power grid investment to adapt to the new situation, improve the power grid investment quality effect level, clarify the development mechanism, optimize decision-making technology and methods, promote the development of power grid investment quality news comb above problems from the source, summarizes the concise advanced concept and application scenarios, power grid investment service "double carbon" quality transfer efficiency and high quality development.

Literature [1] Based on the construction of GMRIO model, using the non-competitive input-output table of comparable prices from 2007 to 2019, the measurement and structure decompose the implied carbon of agricultural export added value of major countries in Asia, North America and the European Union. The research shows that the transformation of China's agricultural export trade has achieved initial results, and the implied carbon of the added value of agricultural export decreases rapidly, but it is still higher than the major developed economies. The sharp decline of agricultural carbon emission intensity is the key factor for the optimization of agricultural export scale, appropriately increase the transfer of other countries to the agricultural export value, increase the export competitiveness of some low-value, and increase the comprehensive added value of Chinese agricultural export. Literature [2] Based on the construction of GMRIO model, using the non-competitive input-output table of comparable prices from 2007 to 2019, the measurement and structure decompose the implied carbon of agricultural export added value of major countries in Asia, North America and the European Union. The research shows that the transformation of China's agricultural export trade has achieved initial results, and the implied carbon of the added value of agricultural export decreases rapidly, but it is still higher than the major developed economies. The sharp decline of agricultural carbon emission intensity is the key factor for the optimization of agricultural export scale, appropriately increase the transfer of other countries to the agricultural export value, increase the export competitiveness of some low-value, and increase the comprehensive added value of Chinese agricultural export. Literature [3] adopts the multi-region input-output model to calculate the trade implied carbon quantity and transfer direction of 27 industries in 20 provinces in 2015 and 2017 from the

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perspective of added value, describe the spatial network structure characteristics of trade implied carbon with the help of social network analysis, and analyze the driving factors of implied carbon. It is found that the interprovincial carbon transfer in China presents a network structure of accessibility, complexity and heterogeneous, and the spatial correlation effect of implied carbon is obvious. The cluster analysis of block model shows that there is an obvious phenomenon of carbon transfer to less developed areas in China. The QAP regression results showed that geographical factors, industrial structure and factor endowment had a significantly positive influence on the spatial correlation of carbon transfer. Literature [4] On the basis of analyzing the development of the whole life cycle carbon measurement of foreign construction projects, the whole life cycle carbon measurement calculation model of low-carbon construction projects is constructed, and the problems and improvement suggestions of the whole life cycle carbon measurement of low-carbon construction projects are put forward.

Literature [5] selected China and Indonesia as the research object, and used the multi-regional input-output method to measure the embodied carbon transfer of their trade, and the results showed that China was in the position of net export of embodied carbon, and the industries with more embodied carbon were basic metal manufacturing, chemical products, machinery manufacturing, quarrying and mining, coke refining and petroleum industry, etc. Through the LMDI method, the factors affecting the change of embodied carbon are decomposed into scale effect, structural effect and intensity effect, and it can be seen that the scale effect is positive, which is the main factor leading to the increase of embodied carbon in China's exports. The structural effect did not play its due role, which also promoted the increase of embodied carbon, but in stages, the structural effect in China improved. The intensity effect has always been a factor that inhibits the increase of embodied carbon in China's exports, but from a phased point of view, China's production technology needs to be improved, and the energy consumption structure and efficiency need to be improved and improved. In summary, in order to reduce China's carbon emissions, develop a low-carbon economy, and build a green "Belt and Road", the following policy suggestions are proposed: promote the green development of China's industry; improve the structure of China's export trade; improve the energy consumption structure and improve the utilization efficiency; improve the level of production technology and promote cleaner production; strengthening regional climate governance and cooperation; Strengthen the voice of international climate negotiations. Literature [6] formed an input-output table for MRIO for each industrial sector involved in international trade, obtained a refined MRIO measure of embodied carbon in China's manufacturing trade, and decomposed the embodied carbon effect of MRIO manufacturing trade according to the embodied carbon efficiency effect, technology effect and corresponding structure and scale effect of manufacturing export trade. In Ref. [7], multiple linear regression models and panel regression models were constructed to empirically study the impact of agricultural support policies on the embodied carbon of China's agricultural export trade, and to analyze the differences in the impact of different agricultural support policies and product heterogeneity. Finally, with the help of exponential decomposition and partial least squares path analysis model, the specific impact path of different agricultural support policies on the embodied carbon of China's agricultural export trade is analyzed. Based on the input-output table of comparable prices for continuous time from 2000 to 2017, the embodied carbon of manufacturing export trade in Zhejiang Province was calculated on this basis. Ref. [8] uses the structural decomposition method to decompose the factors affecting the growth of embodied carbon emissions of exports to the United States into energy use efficiency, production technology, export scale to the United States, and export structure to the United States, and the results show that the improvement of China's energy use efficiency and production technology have contributed to the reduction of embodied carbon emissions of exports to the United States, in which the improvement of energy use efficiency plays a major role, while the scale and structure of exports to the United States lead to the increase of embodied carbon emissions of export commodities. Ref. [9] formed an input-output table for MRIO for each industrial sector involved in international trade, obtained a refined MRIO measure of embodied carbon in China's manufacturing trade, and decomposed the embodied carbon effect of MRIO in manufacturing trade according to the embodied carbon efficiency effect, technical effect and corresponding structure and scale effect of manufacturing export trade. Ref. [10] uses the input-output model to measure the embodied carbon emissions of Sino-US trade based on the data of China's input-output table from 2000 to 2010, and the results show that China bears a huge amount of embodied carbon emissions from U.S. consumption, among which mechanical and electrical products have always been the main sector of embodied carbon emissions exported to the United States.

In summary, the current method of carbon measurement and analysis of power grid engineering is still blank, which can not effectively guide the investment and construction of power grid engineering, so this research is very necessary.

2. Model construction and data processing

2.1 Model construction

Implied carbon in power grid projects can be measured by using input-output methods. Under the framework of the input-output table, the total output vector X satisfies the following balance relationship:

$$X = AX + Y \quad (1)$$

$$X = (I - A)^{-1} Y \quad (2)$$

A is the direct consumption matrix. For the input-output table constructed in this paper, A eliminates the

import intermediate input. If y is used to represent the diagonal vector of grid engineering, and Ed is used to represent the diagonal matrix of direct carbon dioxide emission intensity coefficient per unit output, the implied carbon emission vector of grid engineering can be obtained P:

$$P = E_d (I - A)^{-1} y \qquad (3)$$

Order is the proportion of different types of power grid projects in the total number of projects, is the overall investment, u (1,1... 1) is the sum factor. The above formula for (3) is further recorded as:

$$E = uE_d L y_s y_v \qquad (4)$$

Using the structure decomposition analysis method (Leontief & Ford, 1972) can be used in the economic system

The changes of some explanatory variables are decomposed into the sum of the changes of some related but independent explained variables, so as to measure the contribution of the changes of each explained variable to the changes of the explanatory variable. Using SDA, the influencing factors of export implied carbon change can be decomposed into four factors, namely, change effect of energy intensity, change effect of input-output coefficient, structure effect of project type structure and effect of investment scale, see formula (5).

$$\Delta Q = f(\Delta E_d, \Delta L, \Delta y_s, \Delta y_v) \qquad (5)$$

Since using SDA will cause a non-uniqueness problem, if there are n variables, there will be n! The decomposition form. Therefore, this section uses the two-stage decomposition method to decompose the formula for (4), and we can obtain (6), (7), (8), and (9).

Formula (6) is the change effect of carbon dioxide emission intensity, that is, the change of implied carbon in power grid project caused by the change of carbon dioxide emission per unit output caused by the improvement of energy use efficiency or the progress of production technology.

$$f(\Delta E_d) = \frac{1}{2}(u\Delta E_d L^1 y_s^1 y_v^1 + u\Delta E_d L^o y_s^0 y_v^0) \qquad (6)$$

Formula (7) is the fluctuation effect of input-output coefficient, which causes the implied carbon change of power grid projects caused by the change of the use ratio of intermediate products in other industries in various industries due to the change of production technology.

$$f(\Delta L) = \frac{1}{2}(u\Delta E_d^0 \Delta L y_s^1 y_v^1 + uE_d^1 \Delta L y_s^0 y_v^0) \qquad (7)$$

Formula (8) is the structure effect of power grid project type, and the overall implied carbon change caused by the change of the change proportion of project type.

$$f(\Delta y_s) = \frac{1}{2}(uE_d^0 L^0 \Delta y_s y_v^1 + uE_d^1 L^1 \Delta y_s y_v^0) \qquad (8)$$

Formula (9) is the investment scale effect, the overall implied carbon change caused by the change in the amount of project investment and construction

$$f(\Delta y_v) = \frac{1}{2}(uE_d^0 L^0 y_s^0 \Delta y_v + uE_d^1 L^1 y_s^1 \Delta y_v) \qquad (9)$$

2.2 Data collection and processing

The implied carbon measurement calculation of export trade is based on the input-output table. However, due to the large amount of input-output table compilation, the long period of table compilation also affects the research timeliness of input-output related research fields. Secondly, the input-output table is based on the producer price of the same year, and there are some difficulties in the comparability of value variables. To this end, in order to measure the hidden carbon of the grid project and analyze the reasons for its changes

Build a continuous time comparable price input-output table to reflect the change in the proportion and structure of each sector, as well as the energy economic and technological relationship of each sector.

2.3 Calculation of carbon dioxide emissions

This paper includes the 19 terminal energy consumption quantities in China Energy Statistical Yearbook, and reduces the carbon dioxide emissions in Zhejiang province according to formula (10). The energy consumption comes from China Energy Statistical Yearbook over the years.

$$C = \sum_{i=1}^{n} C_i = \sum_{i=1}^{n} E_i \times NCV_i \times CC_i \times COF_i \times \frac{44}{12} \qquad (10)$$

3. Empirical analysis

This paper relies on the actual data of 6 county-level power grid companies in a region in the past four years to carry out empirical analysis. The data collection and collation results are shown in Table 1 below:

Table 1. Implied carbon data collection of 6 county-level power grid companies in a certain region in recent 4 years (10,000 tons).

Corporate name	2019	2020	2021	2022
A company	12.4509	34.8862	43.8336	42.7052
B company	1.6888	6.9586	10.5802	9.7267
C company	8.4448	33.5466	34.6371	30.6491
D company	1.6517	7.3517	12.8207	10.9362
E company	5.9405	21.1233	22.5517	23.7974
F company	0.8466	2.3991	3.3155	3.0198
Amount to	31.0233	106.2655	127.7388	120.8345

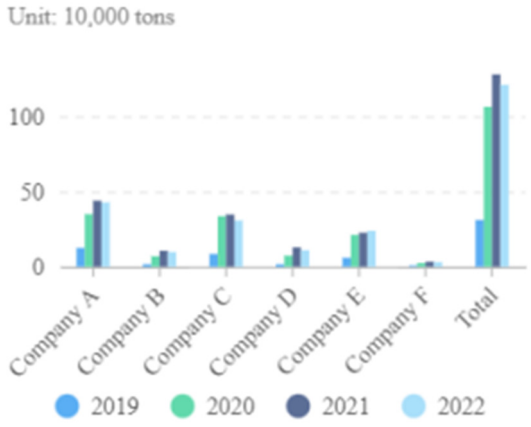

Figure 1. Changes in embodied carbon data of six county-level power grid companies in the past four years.

As can be seen from Table 1 and Figure 1, the embodied carbon of the six county-level power grid companies in the region has generally shown a growing trend in the past four years. Among them, Company A has the fastest growth rate, and Company F has the slowest growth rate, which is mainly closely related to the speed of regional economic development and the electricity sales of the power grid.

Using formulas (6), (7), (8), (10), comparable price input-output table for 2019,2020,2021 and 2022 and the previous data processing method, the changes of implied carbon in power grid investment projects of power grid companies can be decomposed into four factors. The results are shown in Table 2.

Table 2. Hidden carbon structure decomposition of power grid investment projects.

	2019	2020	2021	2022
ΔE_d	-32.2414	-26.0690	-11.6034	-32.2414
ΔL	29.0086	10.6983	-32.4569	29.0086
Δy_s	-0.1034	1.4052	-1.1034	-0.1034
Δy_V	78.5776	35.4397	38.2500	78.5776
Amount to	75.2414	21.4741	-6.9138	75.2414

As can be seen from Table 1 and Table 2, during the stage of 2019 to 2022, the implied carbon of power grid companies increased from 310,233 tons to 1.208345 tons, the net increase of implied carbon was 898,112 tons, and the implied carbon increased by 2.89 times.

4. Conclusion

This paper puts forward the implicit carbon measurement and structure decomposition technology of power grid engineering based on the structural analysis method, and expounds the application method and application effect of the technology combined with the empirical analysis, so as to provide support and reference for the project type division and scientific decision-making under the new situation of power grid enterprises.

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