Characteristic Analysis of Implicit Power Flow in Jiangsu Province——Based on the Perspective of Industry Chain

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Abstract. The huge power consumption has brought greater pressure to the Jiangsu power grid to ensure supply. In order to ensure the safe and stable supply of electricity in Jiangsu Province, it is necessary to conduct an in-depth analysis of the implied electricity consumption of various industries in the province, and to clearly present the electricity consumption of various industries due to final demand. In this paper, the input-output model is used to measure the implicit power flow in Jiangsu Province, thereby clarifying the implicit power consumption generated by different industrial sectors and the transfer path of implicit power consumption between industries. Based on the characteristic analysis, we put forward some targeted policy suggestions. This paper can provide reference to build a new model for constructing a new power system and optimizing the industry power demand structure in Jiangsu province.

Keywords. Implicit power flow; Industrial chain effect; Electric consumption

1. Introduction

Jiangsu Province is a major economic province in China, as well as a large electricity consumption province. In 2021, the electricity consumption of the whole society in Jiangsu will be 710.1 billion kWh, accounting for 8.5% of the country's total electricity consumption. At the same time, Jiangsu's annual maximum electricity load reached 120.4 million kilowatts. From the perspective of different industries, the growth rate of electricity consumption in Jiangsu Province's transportation, information transmission, wholesale and retail, leasing business services and other industries has exceeded 20%. The huge power consumption has brought greater pressure to the Jiangsu power grid to ensure supply. However, Jiangsu power grid has the development characteristics of load diversification and demand differentiation. Meanwhile, the traditional power supply side has the characteristics of large planning investment, long cycle and low environmental friendliness [1]. Therefore, it is necessary to reduce the burden on the power system from the demand side.

At present, Jiangsu Province's energy-saving and emission-reduction programs often focus on high-energy-consuming industries such as steel, cement, and chemical industry [2]. These industries are indeed the key links in promoting energy conservation and emission reduction. However, one-sided emphasis on high-energy-consuming industries tends to ignore other industries that affect the production of products and power consumption in high-energy-

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consuming industries themselves. The implied electricity consumption of an industry refers to the total electricity consumed to meet the final demand of the industry. In order to ensure the safe and stable supply of electricity in Jiangsu Province, it is necessary to conduct an in-depth analysis of the implied electricity consumption of various industries in the province. Only in this way can we clearly present the power consumption of various industries due to final demand, and provide theoretical support for formulating industry-level "power saving" programs.

However, there is a lack of research on industry implied power consumption in Jiangsu Province in the existing literature. Since the production of products is accompanied by electricity consumption, it is of theoretical and practical significance to discuss the industry composition of implied electricity consumption in Jiangsu Province. Considering the insufficiency of the existing literature, this paper uses the input-output model to estimate the implicit power flow in Jiangsu Province. Through calculation, this paper clarifies the implicit power consumption generated by different industrial sectors in Jiangsu Province and the transfer path of implicit power consumption between industries, so as to put forward targeted policy suggestions. Overall, this paper can provide a reference for Jiangsu Province to build a new power system and optimize the industry power demand structure.

2. Model construction

When estimating the implied power consumption in Jiangsu Province, in addition to the direct power consumption of the end-use related industries, it is also necessary to consider the power consumption of the intermediate inputs in the production process of these industries. Input-output analysis can accurately calculate the implicit electricity consumption of an economic sector [3,4]. The advantage of this method is that it does not need to consider the length and complexity of the production process, so it is suitable for this study. Input-output table is the basis of input-output analysis, and its final use includes items such as household consumption, government consumption, capital formation, and export [4,5]. According to the analysis of the final use of different industries by different subjects in the input-output table, the main sectors that affect the final use of electricity consumption can be identified. Specifically, this paper takes China's 2017 inter-regional non-competitive input-output table as the data base, and obtains the energy consumption data of Jiangsu Province in 2017 according to the "Jiangsu Statistical Yearbook 2018". Subsequently, this paper collects and sorts out the input-output data about Jiangsu Province, constructs the Jiangsu Province energy input-output database, and finally compiles the Jiangsu Province's input-output table.

Since this paper only measures the implicit power flow in Jiangsu Province, the single-region input-output model is used to measure the implicit power consumption. According to the basic linear equation of the regional input-output model, the following formula can be obtained:

$$X = (I - A)^{-1} F \tag{1}$$

Where $X = \begin{pmatrix} X^1 \\ X^2 \\ \vdots \\ X^n \end{pmatrix}$, $A = \begin{pmatrix} A^{11} & A^{12} & \cdots & A^{1n} \\ A^{21} & A^{22} & \cdots & A^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A^{n1} & A^{n2} & \cdots & A^{nn} \end{pmatrix}$, $F = \begin{pmatrix} f^{11} & f^{12} & \cdots & f^{1n} \\ f^{21} & f^{22} & \cdots & f^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ f^{n1} & f^{n2} & \cdots & f^{nn} \end{pmatrix}$,

$X = (X_i^s)$ is the total output vector, X_i^s is the total output of the regional s sector i. I is the identity matrix, thus $(I - A)^{-1}$ is the Leontiff inverse matrix. Technical coefficient submatrix $A^{rs} = \left(a_{ij}^{rs}\right)$, and $a_{ij}^{rs} = z_{ij}^{rs} / x_j^s$, while z_{ij}^{rs} represents the flow from the department i of the region r to the department of j the region s. Thus, x_j^s is the total output of department j in region s. $F = (f_i^{rs})$ is the final demand matrix composed of the sum of domestic household consumption, government consumption, fixed capital formation, and inventory changes. f_i^{rs} is the region's final demand for j sector products from the region r.

3. Result analysis

Figure 1 shows the implied electricity consumption in Jiangsu Province. It can be seen from Figure 1 that more than 80% of the electricity consumption of various industrial sectors in Jiangsu Province is consumed by the secondary industry. However, by tracing the electricity consumption footprint of Jiangsu Province, it can be found that electricity consumption of the secondary industry is ultimately transferred to consumption, investment and net exports. From the perspective of implied power consumption, the implied power consumption of household consumer goods is 158.66 billion kWh, and the implied power consumption of government consumption is 43.12 billion kWh. Comparably, the implied electricity consumption of investment was the highest at 279.57 billion kWh, and the implied electricity consumption of net exports was also as high as 99.6 billion kWh.

From the perspective of the flow of implied power consumption, the direct power consumption of the primary industry is relatively small, and it is mainly transferred to household consumption. The direct power consumption of the secondary industry reached 492.96 billion kWh, of which 124.86 billion kWh was transferred to household consumption, 23.63 billion kWh was transferred to government consumption, 248.85 billion kWh was transferred to investment, and 95.62 billion kWh was transferred to Net exports. The direct power consumption of the tertiary industry was 82.01 billion kWh, of which 29.14 billion kWh was transferred to household consumption, 18.95 billion kWh was transferred to government consumption, 29.90 billion kWh was transferred to investment, and 4.02 billion kWh was transferred to net electricity Export. By analyzing the transfer path of implicit power, it can be found that the implicit power consumption of the tertiary industry is mainly used for household consumption, government consumption and investment.

However, due to the large scale of power consumption implied by investment, the proportion of power consumption transferred from the tertiary industry is not high. Although the implied power consumption of household consumption also mainly comes from the secondary industry sector, the transfer ratio of the tertiary industry is also close to 20%. The main form of government consumption is government purchase, and the source is mainly input from the tertiary industry, so the proportion of its implied power consumption from the tertiary industry is about 40%. The implied power consumption of net exports is relatively large. Among all power consumption in Jiangsu Province, 99.60 billion kWh is used for net exports. And more than 95% of them (95.62 billion kWh) are from the transfer of the secondary industry, which shows that changes in foreign trade will also have a greater impact on energy and electricity consumption in Jiangsu Province.

In addition to direct electricity consumption in Jiangsu Province, 70.99 billion kWh of electricity consumption in final use in Jiangsu Province comes from inter-provincial net flows. This is mainly due to the relatively developed economy of Jiangsu Province and the relatively poor endowment of energy resources. In the division of labor among domestic provinces, Jiangsu occupies an upstream position in the industrial chain. Jiangsu Province purchases many intermediate inputs with high energy intensity from other provinces, and the proportion of manufactured goods in output is high. Therefore, there is an implicit net transfer of electricity from other provinces to Jiangsu, that is, electricity consumption occurs in other provinces, but is transferred to Jiangsu in the form of intermediate products.

Through the input-output model, it is also possible to further analyze the industry sector sources of implied power consumption in different types of end uses, as shown in Table 1 below. It can be seen from Table 1 that the final flow characteristics of electricity consumption in different departments are quite different. Here only a few representative sectors are taken as examples for analysis. Textiles are an important sector in Jiangsu Province's economy and also a major sector of electricity consumption. The electricity consumption of the textile industry was 46.66 billion kwh, of which 22.95 billion kwh was transferred to net exports, and another 7.38 billion kwh was transferred to outflows outside the province. This is mainly because Jiangsu is a major textile province, and most of its textile products are sold to the international market and other domestic provinces. In these textiles exported or flowed to the domestic market, a large amount of electricity consumption is implied. In contrast, the implied electricity consumption of textiles in the household consumption of Jiangsu Province is only 11.93 billion kWh. Chemical products are another major power-consuming sector in Jiangsu Province, with power consumption reaching 77.82 billion kWh. 29.24 billion kWh of electricity consumption for chemical products was transferred to domestic and foreign outflows. This is mainly due to the relatively developed chemical industry in Jiangsu, and the large-scale supply of chemical products to outside the province, and these products contain a large amount of electricity consumption that occurs in the province of Jiangsu.

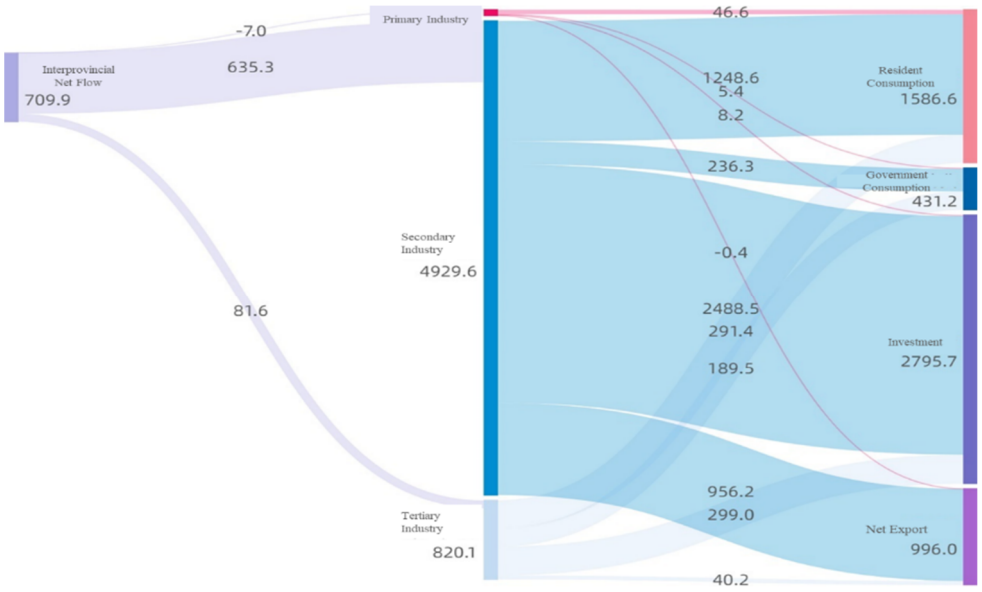

Figure 1 Implied power flow in Jiangsu Province (100 million kWh)

In addition, some of Jiangsu's chemical products are exported, and the electricity consumption implied by the net export of chemical products is 7.88 billion kWh. Consumption and investment in Jiangsu Province also have a greater demand for chemical products. Specifically, among the electricity consumption of chemical products, 15.93 billion kWh was transferred to household consumption, 5.71 billion kWh was transferred to government consumption, and 19.07 billion kWh was transferred to investment. Among other industrial sectors in Jiangsu Province, major power consuming sectors such as "metal products", "general equipment", "special equipment", "electrical machinery and equipment", "communication equipment, computers and other electronic equipment" also showed similar Similar characteristics of the chemical products sector will not be repeated here.

Some special discoveries are also available. Although some departments have low electricity consumption in the province, they use a large number of products from relevant departments through net inflows from outside the province, so there is a high implied electricity inflow. These divisions include "Coal Mining Products", "Metallic Mining Products", "Non-Metallic Mining and Other Mining Products", "Metal Products", and "Machine and Equipment Repair Services", among others. The reason is that due to the resource endowment or the division of labor in the industrial chain in Jiangsu Province, these industry sectors do not have comparative advantages, so the output is not high. However, the consumption and investment of Jiangsu Province have demand for the products of these sectors, so it is mainly supplied by other provinces in China, which leads to the transfer of implied power consumption accordingly.

Table 1 Implied sources of electricity for different types of end use (unit: 100 million kWh)

Sector	Household Consumption	Government Consumption	Investment	Domestic Outflows	Net Exports	Total
Agriculture, forestry, animal husbandry and fishery products and services	46.6	5.4	8.2	7.0	-0.4	66.8
Coal mining products	35.9	6.3	59.4	-110.3	15.8	7.2
Oil and gas extraction products	21.3	4.2	25.2	-53.3	3.5	1.0
Metal ore mining products	35.9	6.5	128.8	-165.9	-1.1	4.1
Non-metallic ores and other mining products	13.4	3.1	61.7	-76.1	5.2	7.3
Food and tobacco	60.9	2.4	6.4	7.3	2.4	79.3
Textile	119.3	11.6	32.3	73.8	229.5	466.6
Garments, shoes, hats, leather, down and their products	20.3	1.7	1.2	5.1	22.3	50.6
Woodwork and furniture	9.2	0.8	20.3	2.4	11.2	43.9
Paper printing and cultural, educational and sporting goods	20.7	5.2	17.7	2.7	12.6	59.0
Petroleum, coking products and nuclear fuel processed products	28.0	6.1	36.3	-37.2	7.5	40.8
Chemical product	159.3	57.1	190.7	292.4	78.8	778.2
Non-metallic mineral products	20.4	3.8	245.6	-90.2	15.5	195.1
Metal smelting and rolling processed products	92.8	16.5	338.7	-85.3	129.3	491.9
Metal products	40.6	8.4	113.7	58.9	65.2	286.8
General equipment	11.6	2.5	80.1	48.6	23.7	166.5
Professional setting	10.4	5.3	72.2	56.6	11.9	156.4
Transportation equipment	31.4	2.6	13.5	47.1	15.2	109.9
Electrical machinery and equipment	14.4	1.5	33.8	177.9	35.3	262.9
Communication equipment, computers and other electronic equipment	27.2	3.0	30.7	115.1	73.2	249.2
Instrumentation	6.3	1.3	6.5	50.0	-3.6	60.5
Other manufactured products and scrap	86.7	18.0	135.5	-220.4	39.4	59.2
Metal Products, Machinery and Equipment Repair Services	37.5	8.2	66.6	-138.4	26.9	0.8
Production and supply of electricity and heat	285.9	53.4	430.5	-281.8	128.7	616.7
Gas production and supply	5.0	0.3	0.9	0.9	0.3	7.3
Production and supply of	51.9	6.2	279.9	-299.1	7.5	46.4

water						
Architecture	2.1	0.3	60.2	-15.9	0.1	46.8
Wholesale and retail	55.9	5.0	35.1	39.8	14.5	150.3
Transportation, warehousing and post	36.2	17.0	47.4	-31.7	14.3	83.2
Accommodation and meals	34.2	5.4	11.9	-2.3	2.5	51.7
Information transmission, software and information technology services	12.5	2.8	14.2	22.7	0.7	53.0
Finance	8.5	0.7	5.0	-3.2	0.7	11.6
Real estate	81.7	11.1	151.3	-126.1	3.3	121.2
Rental and business services	15.7	2.8	15.2	6.8	2.9	43.3
Research and trial development	0.0	2.0	4.0	3.0	0.0	9.0
Comprehensive technical services	1.1	1.7	6.8	-1.4	0.2	8.4
Water, environment and utilities management	2.9	37.4	2.0	5.1	0.2	47.6
Residential services, repairs and other services	8.1	1.6	3.4	-0.2	0.6	13.5
Education	19.5	34.2	1.3	-4.3	0.2	51.0
Health and social work	10.5	28.3	0.0	-0.1	0.0	38.7
Culture, sports and recreation	3.9	2.1	0.6	10.3	0.1	17.1
Public administration, social security and social organization	0.7	37.4	0.7	0.2	0.1	39.1

4. Conclusion

This paper uses the input-output model to measure the implicit power flow in Jiangsu Province. In specific, we analyze the implicit power consumption generated by different industrial sectors in Jiangsu Province and detect the transfer path of implicit power consumption between industries. The core research conclusions mainly include the following three aspects.

First, the implied electricity consumption of investment, household consumption and net export ranked the top three, with 279.57 billion kWh, 158.66 billion kWh and 99.6 billion kWh respectively. Implied electricity consumption in government consumption was the lowest at 43.12 billion kWh. From the perspective of the flow of implied power consumption, the implied power consumption of household consumption and investment mainly comes from the secondary industry sector, and the implied power consumption of government consumption comes from the input of the tertiary industry, accounting for about 40%.

Secondly, there are great differences in the final flow characteristics of electricity consumption in different sectors. The electricity consumption of the textile industry was 46.66 billion kwh, of which 22.95 billion kwh was transferred to net exports, and another 7.38 billion kwh was transferred to outflows outside the province. This shows that there is a lot of

power consumption implicit in the textiles sold from Jiangsu Province. 29.24 billion kWh of electricity consumption in the chemical products industry was transferred to domestic and foreign outflows.

Finally, although the electricity consumption in the sectors such as “Coal Mining and Processing Products”, “Metallic Mining and Processing Products”, “Non-metallic Mining and Other Mining and Processing Products”, “Metallic Products”, and “Machine and Equipment Repair Services” is low, but there is a higher implied power input. This is mainly because the situation of resource endowment or the division of labor in the industrial chain in Jiangsu Province.

Based on the relevant conclusions, this paper puts forward some targeted policy suggestions to improve the mechanism design of the Jiangsu provincial government. (1) The implied electricity consumption ultimately used for household consumption in Jiangsu Province accounts for about 22% of the province's total electricity consumption in 2021. Therefore, it is necessary to enhance the awareness of energy conservation and emission reduction of residents in Jiangsu Province, and guide residents to use electricity rationally. (2) The final flow characteristics of electricity consumption in different sectors are quite different. Therefore, policy design needs to shift from a production-oriented model that only focuses on electricity consumption on the production side to a multi-industry comprehensive governance model that considers both the production side and the demand side. (3) Some departments have low power consumption, but there is a high implied power input. In the future, the final demand structure of these industries should be adjusted to be energy-efficient, their production structure should be optimized, and intermediate inputs should be reduced.

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