

Research on Energy Consumption Intensity Based on Structure Share and Efficiency Share

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Abstract. With the rapid development of economy, the contradiction between energy supply and demand is increasing. Energy shortage has seriously restricted the healthy development of China's economy. Research on energy consumption is of great significance to build a resource-saving society and promote the sustainable development of economy. According to the Hebei Province industrial structure and energy consumption status, this paper decomposes the energy consumption intensity into structure share and efficiency share, and analyzes the effect of industrial restructuring and energy efficiency on the overall energy consumption intensity. The empirical results show that the energy consumption intensity of Hebei province is declining in the research period, which is the result of energy efficiency improvement and industrial structure adjustment in different industries. The biggest influencing factor is the efficiency share, especially the improvement of energy utilization rate of the second industry. The effect of structural share on energy consumption is small compared to efficiency share. The decreasing of second industrial energy consumption intensity is the main reason for the decline in the overall energy from the point of the structure share and efficiency share. Finally, this paper puts forward the ways to reduce the energy consumption from the industrial structure adjustment and other dimensions.

Introduction

With the rapid development of economy, industrialization and urbanization process is accelerating, the economic development has stimulated the rapid growth of energy consumption, the imbalance between energy supply and energy demand has become increasingly prominent, the economic development is faced with more energy restriction and severe pressure on energy and environment. The key to research the problem of energy consumption is to analyze the impact of different factors on the growth of energy consumption. Energy consumption intensity is an important indicator to measure the efficiency of energy use, which reflects the efficiency of energy use in the production process and can evaluate the quality of economic growth and the size of the environmental impact. This paper decomposes the energy consumption intensity into efficiency share and share structure, and analyzes the

cause of the intensity change of Hebei Province energy consumption according to the Hebei Province industrial structure and energy consumption status based on the relevant statistical data from two dimensions of the industrial structure and energy utilization efficiency, so as to provide suggestions to develop the economy development strategy, energy policy and industrial structure optimization for Hebei Province.

Calculation Method of Energy Consumption Intensity based on Structure Share and Efficiency Share

Energy intensity is the amount of energy consumed per unit of output in a country or region, department or industry within a certain period of time, usually expressed in ton of standard coal per million Yuan. There are many factors that affect the energy intensity, such as the reasonable adjustment of industrial structure, the improvement of energy use efficiency, the use of advanced equipment and so on. To measure the degree of impact, it is necessary to decompose and analyze

each influencing factor completely. The intensity of energy consumption is the amount of energy consumed per unit of gross domestic product, expressed in e . Total energy consumption is expressed as E , Y is on behalf of GDP . E_i expresses energy consumption in the i industry, Y_i expresses the GDP of i industry. So $E = \sum E_i$, $Y = \sum Y_i$. g_i indicates the proportion of the output value of the i industry in GDP ($i=1,2,3$), then $g_i = Y_i / \sum_{i=1}^3 Y_i$, in accordance with the three industry E and

Y will be decomposed as: $E = \sum E_i = E_1 + E_2 + E_3$, $Y = \sum Y_i = Y_1 + Y_2 + Y_3$, so decomposes e into:

$$e = \frac{E}{Y} = \frac{\sum_i E_i}{\sum_i Y_i} = \frac{\sum_i e_i Y_i}{\sum_i Y_i} = \sum_i e_i \frac{Y_i}{\sum_i Y_i} = \sum_i e_i g_i, \quad \text{Let } e^n \text{ is the energy intensity of the } n \text{ year, } e^0 \text{ is the energy}$$

intensity of the base period, then: $e^n = \sum_i e_i^n g_i^n$, $e^0 = \sum_i e_i^0 g_i^0$, Composes e^n into:

$$e^n = \sum_i e_i^n g_i^n = \sum_i e_i^0 g_i^0 + \sum_i e_i^0 (g_i^n - g_i^0) + \sum_i (e_i^n - e_i^0) g_i^n. \quad \text{So, the energy intensity change from the base period to } n$$

period is: $\Delta e = e^n - e^0 = \sum_i e_i^n g_i^n - \sum_i e_i^0 g_i^0 = \sum_i e_i^0 (g_i^n - g_i^0) + \sum_i (e_i^n - e_i^0) g_i^n$, $e_i^0 (g_i^n - g_i^0)$ expresses the amount of energy intensity change caused by the proportion change of the i industry in the total output; $\sum_i e_i^0 (g_i^n - g_i^0)$ expresses the amount of energy intensity change caused by the change of overall industrial structure. So the structure share in the change of energy consumption intensity during the n period is:

$$A = \frac{\sum_i e_i^0 (g_i^n - g_i^0)}{\sum_i e_i^n g_i^n - \sum_i e_i^0 g_i^0} \quad (1)$$

$(e_i^n - e_i^0) g_i^n$ expresses the amount of energy intensity change caused by the change of energy use efficiency of the i industry; $\sum_i (e_i^n - e_i^0) g_i^n$ expresses the amount of energy intensity change caused by the changes of energy use efficiency in all industries. So, the efficiency share in the change of energy consumption intensity during the n period is:

$$B = \frac{\sum_i (e_i^n - e_i^0) g_i^n}{\sum_i e_i^n g_i^n - \sum_i e_i^0 g_i^0} \quad (2)$$

The formula (1) and (2) express the contribution rate of industrial structure change and energy use efficiency change to total change in energy consumption intensity since the base period. In order to calculate the structure share and efficiency share in the energy consumption intensity change of n period, we take $n-1$ as the base period, the structure share in the change of energy consumption intensity of the n period is :

$$\hat{A} = \frac{\sum_i e_i^{n-1} (g_i^n - g_i^{n-1})}{\sum_i e_i^n g_i^n - \sum_i e_i^{n-1} g_i^{n-1}} \quad (3)$$

$$\hat{B} = \frac{\sum_i (e_i^n - e_i^{n-1}) g_i^n}{\sum_i e_i^n g_i^n - \sum_i e_i^{n-1} g_i^{n-1}} \quad (4)$$

The formula (3) and (4) express the proportion of effect of structure change and energy efficiency change in intensity variation of energy consumption in the n period. if the structure share and efficiency share is positive, it indicates that the driving force of the structure and the change of energy consumption intensity are the same direction; if it is negative, it indicates that the impact direction and the change of energy consumption intensity is reverse.

Empirical Analysis

Economic Aggregate, Industrial Structure and Energy Consumption Trend in Hebei Province. Since 2000, Hebei Province's economy continued to grow rapidly, GDP increased from 504 billion

396 million yuan in 2000 to 2 trillion and 942 billion 115 million yuan in 2014 with an average annual growth rate of 13.57%, which is an increase of 4.83 times, per capita GDP increased from 7592 yuan in 2000 to 39984 yuan in 2014. From the point of view of industrial structure (shown in Figure 1), the proportion of primary industry is decreasing, which is due to a relatively high degree of industrialization in 2000. It shows that the secondary industry and the tertiary industry are gradually replacing the position of the primary industry, the industrial structure is gradually optimized. The primary industry fell from 16.35% in 2000 to 11.72% in 2014, the secondary industry change is not very obvious, the proportion has accounted for about 50%, The proportion of the tertiary industry has increased year by year, from 33.79% in 2000 to 37.25% in 2014.

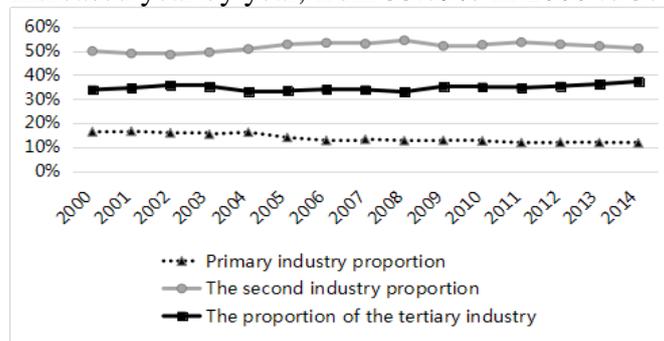


Fig.1. Industrial Structure Change

Heavy industrial structure has led to high energy consumption in Hebei province. In 2012, the total amount of energy consumption in Hebei province reached 302 million tons, ranking second in China, From the industrial energy consumption point of view, the total amount of energy consumption in Hebei province has continued to rise from 2000 to 2011. The primary industry's energy consumption rose to 7.075 million tons standard coal in 2012 from 1.7286 million tons standard coal in 2000, an average annual growth rate is 15.33%, remained at around 1% to 3% in the total energy consumption. The secondary industrial energy consumption increased from 53.1502 million tons standard coal in 2000 to 244.836 million tons standard coal in 2012, an average annual growth rate is 14.44%, which has been maintained at more than 70% in total energy consumption and presents an upward trend. The tertiary industrial energy consumption increased to 23.844 million tons standard coal in 2012 by 5.4013 million tons standard coal in 2000, an average annual growth rate is 15.33%.

Analysis on the Change Trend of Energy Consumption Intensity in Hebei Province. The general trend of economic gross and energy consumption determines the basic trends and changes of energy consumption intensity in Hebei province. Energy intensity data values are shown in Table 1.

Table 1 Data Value of Energy Intensity in Hebei Province From 2005 to 2012

Year	Energy intensity value	Year-on-Year	Primary industrial energy intensity	Year-on-Year	Secondary industrial energy intensity	Year-on-Year	Tertiary industrial energy intensity	Year-on-Year
2005	1.96		0.38		2.799		0.413	
2006	1.895	-2.04%	0.381	0.26%	2.7	-3.54%	0.401	-2.91%
2007	1.843	-4.17%	0.383	0.52%	2.554	-5.41%	0.374	-6.73%
2008	1.727	-5.98%	0.324	-15.40%	2.316	-9.32%	0.343	-8.29%
2009	1.64	-5.20%	0.307	-5.25%	1.985	-14.29%	0.312	-9.04%
2010	1.583	-3.66%	0.301	-1.95%	2.003	0.91%	0.298	-4.49%
2011	1.31	-17.09%	0.24	-20.27%	1.8	-10.13%	0.26	-12.75%
2012	1.14	-12.98%	0.2	-16.67%	1.66	-7.78%	0.24	-7.69%

Figure 2 shows the change of energy consumption intensity in different industries. As can be seen, the impact of the three industries and energy consumption on the energy consumption intensity of primary industry and the tertiary industry is very small, basically maintained a slight decline in stability, The secondary industry shows a consistent downward trend with the overall energy consumption intensity.

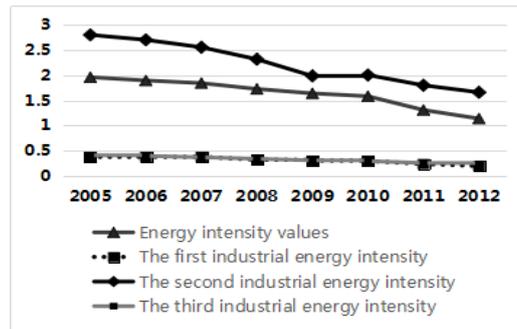


Fig. 2. Trends in the Energy Intensity of Each Industry

According to Table 1, the average decline rate of the primary industry is 8.4%, the average decline rate of secondary industry is 7.08%, the average decline rate of tertiary industry is 7.4%. As can be seen, in recent years, Hebei province has made some achievements in energy use efficiency, the energy intensity of each industry has decreased year by year, indicating that the energy use efficiency is gradually improving. It is inseparable with the government measures, such as implements energy-saving emission reduction responsibility, strictly controls high energy consuming and high polluting industries too fast growth, accelerates the elimination of backward production capacity and so on .

The Influence of Industrial Structure Change and Efficiency Improvement on Energy Consumption Intensity. According to the formula of the structure share and efficiency share, the energy consumption intensity and energy consumption intensity of each industry in Hebei province in 2005 -2012 were calculated, and the calculation results are shown in Table 2.

Table 2 Structure Share and Efficiency Share in Energy Consumption Intensity Change of Hebei Province During 2005-2012

Year	2006	2007	2008	2009	2010	2011	2012
Structure Share	-37.6%	8.8%	-26.5%	20.2%	69.5%	-15.90%	13.3%
Efficiency Share	137.6%	91.2%	126.5%	79.8%	30.51%	115.9%	86.7%

A Comparative Analysis of the Structure Share and Efficiency Share of Energy Consumption in Different Industries. The calculation results of each industry’s structure share and efficiency share are shown in Table 3, the comparison of structure share of each industry is shown in Figure 5, the comparison of efficiency share of each industry is shown in Figure 4.

Table 3 Proportion Structure Share and Efficiency Share in Energy Intensity

Year	2006	2007	2008	2009	2010	2011	2012
Structure Share	-37.6%	8.8%	-26.50%	20.2%	69.5%	-15.9%	13.3%
Primary Industry	11.41%	-2.12%	1.81%	-0.13%	-5.91%	1.89%	-0.30%
Secondary Industry	-42.96%	10.27%	-31.15%	23.56%	82.35%	-18.77%	15.49%
Tertiary Industry	-6.07%	0.64%	2.75%	-3.32%	-6.94%	0.90%	-1.82%
Efficiency Share	137.6%	91.2%	126.5%	79.8%	30.5%	115.9%	86.7%
Primary Industry	-0.24%	-0.32%	6.45%	0.95%	-6.03%	6.47%	4.86%
Secondary Industry	128.14%	81.76%	111.25%	74.28%	75.60%	97.63%	74.73%
Tertiary Industry	9.95%	9.63%	8.78%	4.70%	-39.12%	11.77%	7.19%

According to Figure 4, the average contribution of the efficiency share on the energy intensity is 95.45%. Among them, the proportion of the secondary industry's efficiency share is the largest, the contribution is particularly evident, the average contribution reached 91.97%. The contribution of the primary industry and the tertiary industry is relatively small, the average contribution of the primary industry is 1.68%, the average contribution of the tertiary industry is 1.83%. According to Figure 5, The average contribution of the structural share is only 4.55%, and even in the 2006, 2008 and 2011, the contribution rate of the structure share to the energy intensity is negative, but the energy intensity is increased. The secondary industry’s structure share is still the largest, among them, the primary industry has contribution to the reduction of energy consumption intensity, while the secondary industry and the tertiary industry have a negative impact on the reduction of energy

consumption intensity.

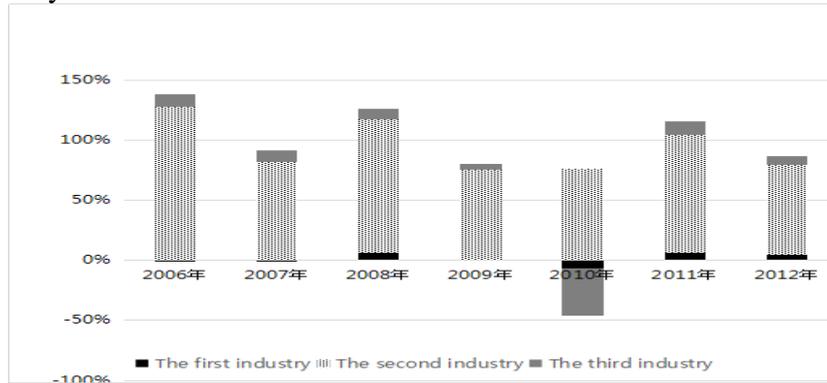


Fig.3. Comparison of Efficiency Share of Each Industry

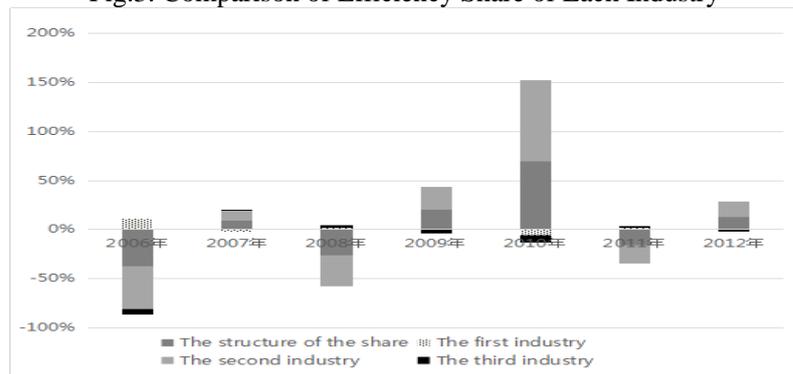


Fig. 4. Comparison of Structure Share of Each Industry

Conclusions

During the research period, the energy efficiency of Hebei province has been greatly improved, but the energy consumption intensity still has a large space for the decrease. In this paper, the energy consumption is decomposed to the structure share and efficiency share, based on the statistical data of 2005-2012 in Hebei province. Compared to the efficiency share, the fluctuation of the influence of the structure share on the energy consumption intensity is larger. Regardless of the efficiency share or from the structure share, the energy consumption intensity decrease of secondary industry is the main motivation of overall energy consumption intensity decrease. In view of the current situation of Hebei Province, the focus of energy consumption intensity should be placed on the secondary industry energy efficiency improvement and the secondary industry energy consumption intensity decrease.

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