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The Analysis and Application of Energy Consumption per Myriad GDP in Shandong Province Based on Entropy Method

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Abstract: With the development of social economy, energy intensity in Shandong has decreased obviously. To solve the issue by taking proper measures, this paper analyze the energy consumption per myriad GDP of 17 cities in Shandong Province based on Entropy Method and rank them according to general energy consumption. It tells the difference of energy consumption in different cities and helps to make measures to solve current energy crisis. This study has certain theory significance and practical application value, the coordinated development of economy and energy development in Shandong province and has certain guiding innovation significance of relevant field.

Keywords: 17 cities in Shandong province, energy consumption per myriad GDP, entropy method

INTRODUCTION

Energy Intensity in Shandong has decreased obviously from 2005 to 2011. This paper analyzes energy consumption per myriad GDP (hereinafter referred as ECPMGDP) of the 17 cities in Shandong in 2005 and 2011.

We know that ECPMGDP of Laiwu is the highest, Duan and Gong (2012) because it's a important steel producer based on ample energy. In recent years, Song *et al*. (2011) Laiwu pay attention to development and use of new technology, thus local iron and steel companies have improved their use ratio of energy (Wang and Zhang, 2001) . Compared with 2005, except Rizhao, energy intensity of the other 16 cities has decreased in 2011. Especially for Jining, the decreasing amplitude is 46.7836%. This shows that government in Shandong show emphasis on the development and use of new energy and in turn energy consumption has deceased. ECPMGDP of Rizhao increased in both 2007 and 2009, (Han *et al*., 2007) especially the value is 2.4 in 2009. Energy intensity in Rizhao has much fluctuation, some department should pay attention (Hu and Wang, 2006; Han *et al*., 2007; Hu and Wang, 2006).

ECPMGDPs of 17 cities can be divided into three degree according to Bar chart in Fig. 1. Dongying, Yantai, Qingdao and Weihai have less consumption; Jinan, Linyi, Weifang, Taian, Binzhou, Dezhou, Heze and Jining have average consumption; Liaocheng, Rizhao, Zibo, Zaozhuang and Laiwu have more consumption (Tangheng, 2006).

We can only see problems in the surface through bar chart instead of finding the root of the matter. Meng and Li (2012) So the paper uses improved entropy method to analyze ECPMGDP, searches for reasons of the matter and then take correct measures (Guo *et al*., 2012) this paper analyze the energy consumption per myriad GDP of 17 cities in Shandong Province based on Entropy Method and rank them according to general energy consumption. It tells the difference of energy consumption in different cities and helps to make measures to solve current energy crisis.

This study analyzes energy consumption per myriad GDP (hereinafter referred as ECPMGDP) of the 17 cities in Shandong in 2005 and 2011. The result is shown in Fig. 1.

This study has certain theory significance and practical application value, the coordinated development of economy and energy development in Shandong province and has certain guiding innovation significance of relevant field (Wang *et al*., 2012).

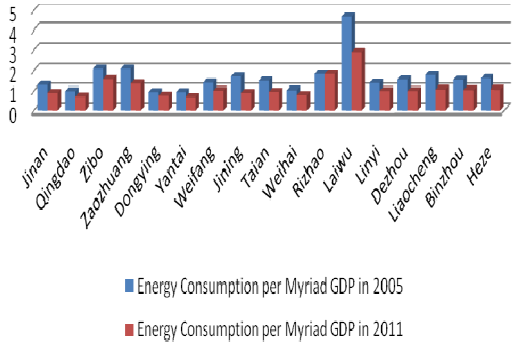

Fig. 1: Energy Consumption per Myriad GDP of 17 Cities in Shandong in 2005 and 2011

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ENTORY METHOD

The paper uses improved entropy method to analyze ECPMGDP of 17 cities. The steps are as follows:

- **Standardizing:** x_{ij} is the value of the $j(j=1,2)$ indicator of the $i(i=1,2,...,17)$ city, ECPMGDP in 2005 is the 1st indicator and ECPMGDP in 2011 is the 2nd one.
  The standard formula is:

$$x_{ij}^{0} = \frac{x_{ij} - x_{\min(j)}}{x_{\max(j)} - x_{\min(j)}} \times 40 + 60$$

  where,
  x_{ij}^{0} : Standardized data
  $x_{max(j)}$: The maximum value of the jth indicator
  $x_{min(j)}$: The minimum of the jth indicator

- Calculating proportion of standardized indicators:

$$R_{ij} = \frac{x_{ij}^{0}}{\sum_{i=1}^{17} x_{ij}^{0}}$$

- Calculating entropy of the jth indicator:

$$e_j = -\frac{1}{\ln 17} \sum_{i=1}^{17} R_{ij} \ln R_{ij}$$

- Calculating diversity factor of the jth indicator:

$$g_j = 1 - e_j$$

- Calculating weight:

$$w_j = \frac{g_j}{\sum_{j=1}^{2} g_j}$$

- Calculating general energy consumption of the ith city $P_i = \sum_{j=1}^{2} w_j R_{ij}$ the bigger P_i is, the bigger ECPMGDP is and the lower the efficiency is

Through general analysis of ECPMGDP in 2005 and 2011, we can rank 17 cities in Shandong (Table 1). The first five cities are Yantai, Qingdao, Dongying, Weihai and Jinan; and the last five cities are Liaocheng, Zaozhuang, Zibo, Rizhao and Laiwu. According to Table 1, government and some department can adjust measures to local conditions. Improve use ratio of energy such as coal and oil while maintaining sustainable efficient growth. Invest more capital, manpower, material and other resources into new energy. Reduce local energy consumption to most extent and make economy sustainably develop.

Table 1: General energy consumption of 17 cities in Shandong

City	P_i	Rank
Jinan	0.055093	5
Qingdao	0.052174	2
Zibo	0.064125	15
Zaozhuang	0.062311	14
Dongying	0.052411	3
Yantai	0.051834	1
Weifang	0.056525	8
Jining	0.056976	9
Taian	0.056468	7
Weihai	0.053052	4
Rizhao	0.065212	16
Laiwu	0.086389	17
Linyi	0.056355	6
Dezhou	0.057061	10
Liaocheng	0.058728	13
Binzhou	0.057386	11
Heze	0.057901	12

RESULT ANALYSIS

The paper divides 17 cities into four main districts aimed at their characters and proposes several suggestions to improve energy efficiency ratio.

Shandong peninsula: Shandong Peninsula is back to the land and near the sea. It has lots of ports and convenient transportation and is the important manufacture base in Shandong. Shandong Peninsula contains Qingdao, Yantai, Weihai and Weifang these four cities. This district should develop manufacture industry, service industry and ocean industry based on Blue Economic Zone.

Firstly, Shandong Peninsula should make full use of ocean. Improve traditional industries such as marine food processing industry, marine chemical industry and Marine logistics. Then develop rising industries such as tourist industry, marine biological medicine and marine new energy and promote construction of marine culture. Secondly, take advantage of geographic position and introduce high technology of Japan and South Korea. Create after learning in order to enhance technical ability and improve added value of productions. Lastly, transfer emphasis from secondary industry to tertiary industry. Develop service industry especially service for production such as information, logistics and financial industry.

This district has the best resources and conditions in Shandong, so we should develop new energy such as solar energy, wind energy source and tidal energy with added investment in scientific research. Take the lead in achieving results and promote development and popularity of total province.

Cities around provincial capital: This district consists of Zibo, Taian, Laiwu, Dezhou and Liaocheng and the core of it is provincial capital Jinan. The cities are in the

midwest of Shandong, located inland and narrowly opening up. As the provincial capital, Jinan need to take advantage of itself, connect with Laiwu, Dezhou and Liaocheng in economy, promote Zibo and Taian in tourism, form region linkage development model. Build strategic industries and take emphasis on tertiary industry. At the same time, develop opening up policy and build good investment environment.

There are many colleges in Jinan, so more encouragement policies and fund can be invested. Cooperate with enterprises, link theory with practice. As for Zibo, support petrochemical, ceramic, textile industry and so on, increase added value with hi-tech. Develop tourist industry in Taian as well as coal, chemical, machineryandso on. As Laiwu consume energy largely, government should introduce hi-tech equipment; produce stainless steel, high-end steel and so on. In that case, build green steel-producing area. In Liaocheng, further processing of nonferrous metals such as aluminium and copper can be promoted. Meanwhile develop tourism characterized by waterside town in the north of the Yangzi River. As for Dezhou, improve its producing ability for new energy equipment.

Efficient ecological economic zone in Yellow River Delta: It's another vital base to promote economy, containing Dongying and Binzhou two cities. Dongying is the centre of Yellow River Delta and Efficient Ecological Economic Zone. There is much oil resource, which must be exploited properly in order to both meet and control needs. Besides, we can construct solar generator and wind-driven generator in the beaches and change single energy structure.

Take the area's unique resources as the basis, establish recycling economy industrial demonstration zone. Use new energy and energy conservation technology to reduce energy consumption of traditional industries. Promote economic growth from extensive to intensive, improve overall industry performance. Take regional advantages to develop modern logistics industry, improve financial services, communications and other services, strive to build petrochemical and salt chemical industry chain and promote the coordinated development of the industrial park.

Economic area in Southern Shandong: This region includes Rizhao, Linyi, Zaozhuang, Heze and Jining five cities. Although it is relatively backward than Shandong Peninsula and Cities around Provincial Capital in the economy, the region has abundant coal reserves and larger coal chemical industry base. Zaozhuang, built and developed as a result of coal, should increase research and development of the desulfurization of coal and clean coal technology. Improve energy efficiency, speed up the adjustment of industrial structure and change current status as a resource-exhausted city. Rizhao should continue to promote and upgrade building materials, machinery, chemicals, textiles and other traditional industries, focusing on building steel, pharmaceuticals and other modern manufacturing. Linyi can be used as the logistics centre, drive around cities to vigorously develop modern logistics industry. Establish port logistics centre in Rizhao, canal logistics centre surround Jining and Zaozhuang, commercial trade logistics centre in Heze, so that the overall logistics enclave is formed.

This region, with a long history and rich culture, is the best area to develop cultural and red tourism. There are Taierzhuang and Weishan Lake Wetland Park in Zaozhuang, Liangshan in Jining, beaches in Rizhao, Mudan Town in Heze, Yimeng landscapes in Linyi, as well as the Beijing-Hangzhou Grand Canal and other unique unforgettable landscapes. On the basis of protection of local ecological environment, government should focus on cultivating high-quality talents about tourism and doing publicity in the area. Form certain relevance between landscapes, improve tourism industry and promote local economy.

DEVELOPMENT PROPOSALS

Based on above analysis, we can see that the energy consumption has been high in recent years in Shandong Province, the foreign dependency continues to rise and energy intensity is generally higher than the eastern coastal provinces. Therefore, maximizing energy efficiency, constantly developing and popularizing new green energy in Shandong are currently serious problems to be solved. It is not only able to sustain rapid coordinated development of economy in Shandong Province, but also to achieve a low-carbon economy, promoting economic and ecological environment to meet urgent needs for sustainable development.

Transforming economic development mode: At present, Shandong is still based on extensive mode of development, energy efficiency is not high and the manufacturing products are generally low value-added. Shandong is still in the low-end position in the global industrial chain. What's more, in the economic development of Shandong Province, tertiary industry takes up the low proportion. Development of manufacturing and service determines the speed of economic growth of a city, is also the backbone of economic growth and competitive advantage. Therefore, adjusting the current unscientific industrial layout in Shandong Province and speeding up the transformation of economic development mode is the most effective way to solve this problem.

In the manufacturing sector, firstly, we must develop new products with independent intellectual property rights. Enhance creativity, increase product's added value and promote the industries from low-end to high-end in the industry chain. Secondly, we must

vigorously promote the development of strategic emerging industries, focusing on R&D of emerging environmentally-friendly energy, information technology, biotechnology and pharmaceutical industries. Vigorously develop marine resources, improve resource efficiency, reduce energy consumption and protect local ecological environment. Thirdly, develop industrial clusters model, with various industrial zones as the core, drive around the region's economic development and brand building, form agglomeration effects and economies of scale.

In the services sector, Shandong Province should gradually reduce the proportion of heavy industry in the secondary industry, focusing on financial and insurance industry, modern logistics, information services and other sectors associated with the economic development. According to the characteristics of each region in Shandong Province, make use of foreign advanced technology and management experience in services for deepening reform and gradually improve service levels in transportation, catering, postal warehousing and other traditional industries.

Improving innovation: Nowadays, economic globalization has resulted in increasing competition. Traditional processing industry has low profits because of lack of high technology. In order to achieve the rapid development of the economy, we must increase R&D investment in high technology. Owning independent core technology means having more initiative in competition in the market.

Compared with other coastal areas in China, Shandong Province is still relatively backward in research and technologies. Shandong should establish incentives guided by governments at all levels based on their own specific circumstances, increase R&D investment, encourage cooperation between enterprises and institutions and promote the industrialization of scientific and technological achievements gradually. At the same time, some departments should develop and improve necessary laws and regulations, increase protection for intellectual property rights, improve management of the market order, maintain normal market competition environment. Create a good living environment for development of independent innovation in an orderly competition in the market.

Adjusting energy structure: Energy consumption is much higher than energy production in Shandong Province in 2011. With the rapid economic development, the contradiction between energy supply and demand will be even more severe. Shandong Province's current energy structure is still relatively simple. It mainly relies on coal consumption to drive economic growth. While the rate of coal combustion is low, combustion also releases harmful substances, doing harms to the surroundings and the residents.

Therefore, in order to fully achieve a low carbon economy and further promote sustainable economic development, Shandong Province should improve utilization rate, reduce the proportion of coal in the energy mix and increase gas, oil and other energies. Increase use of new coal such as anthracite coal, carry out high-efficiency industries such as coal chemical industry, eliminate low-technology and polluting production capacity, strengthen construction and maintenance of power grid, gas pipelines and other energy facilities. Local governments should encourage and support the development and popularization of new energy projects, exploit solar energy, wind energy, tidal energy and other new energies, optimize energy structure, so as to promote economy soundly and rapidly.

Accelerating economic globalization: In economic globalization, the only way to win a place in the fierce market competition is to strengthen self-construction, improve the technological level of their products and ensure product quality. Shandong Province should speed up to change labor-intensive to technology-intensive pattern, increase high-tech research and development, guide targeted foreign investment. Technological innovation has always been an inexhaustible motive force to promote economic development. On the basis of the introduction of foreign advanced production technology, we must constantly learn and innovate, to turn it into our own technology that is suitable for our own development. At the same time, limit high polluting and high consuming industries, curb pollution and consumption of exports and promote exports from simple processing ones to high-tech and high value-added ones.

The coming period is the important time for Shandong Province to transform economic growth mode and adjust industrial structure. The global economy is in bad times because of the financial crisis, but we should also seize this opportunity, continue the self-trimming, accelerate urban transformation and achieve sustainable economic development.

CONCLUSION

This study analyzes ECPMGDP of 17 cities in Shandong Province with the entropy method, based on which, divides 17 cities into four regions and raise recommendations according to the characteristics of different regions. Hope to be helpful energy development in Shandong Province.

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