

An empirical analysis of the economic development, energy structure and energy consumption in Zhejiang Province

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4Since the 21st century, the economy of stable, healthy and rapid development brought a rapid increase in energy consumption. The correct understanding and the analysis of energy consumption in the economic development help to more rationally grasping of the situation of economy and provides a reference for the healthy development of economy and a model for the development of other regions. Based on the data of Zhejiang Province from 1990 to 2016, this paper studies the relationship between energy consumption, energy structure and economic development through empirical analysis, unit root test, Granger causality test. At the same time, it puts forward a series of policy recommendations about how to improve the utilization of energy and accelerate the development of Zhejiang economy.

Key words: Energy consumption, Energy structure, Economic development, Empirical analysis

INTRODUCTION

Energy is the strategic basis for the survival and development of human resources; there are more people and less land, as well as less energy in Zhejiang province; its coal reserves are less than one ten-thousandth of the country proven coal reserves. "No oil, lack of coal, less electricity" means lack of energy, and more than 95% of the energy consumption has to rely on provincial transfer. But it is an "energy consumption province." In 2015, for example, the total energy consumption was 196.1 million tons standard coal which was by about 4.2% over 2014. Among them, the coal consumption was 13.799 million tons standard coal, basically flat with 2014; oil and products consumption was 29.09 million tons, by about 5.3% over the previous year; natural gas consumption was 7.8 billion cubic meters, by about 2.0% over the previous year; consumed electricity from water, nuclear, wind and other sources was 49.6 billion kw·h, about 19.9% over the previous year. The province energy consumption significantly increased, while the economic development showed sudden leaps and bounds in Zhejiang province. From 1990 to 2016, its GDP increased from 90.469 billion yuan to 468.4 billion yuan. The data show that economic development and energy consumption follow the same trend of growth. This paper will start from the above issues, the economic development and the structure of energy consumption, basing on the analysis of energy consumption structure to find better solutions.

CURRENT SITUATION IN ZHEJIANG

The change in total energy consumption

The region lacks energy and has low self-sufficiency rate, although the energy consumption depends on import, it is higher than the national level. The charts can be seen in Fig.1. While the energy consumption continues to grow, the rate of growth declines from the highest rate of 16.07% to the lowest level of 3.86%. At the beginning of the 21st century, owing to the rapid development of economy, some high-energy-consumption basic industries appeared in the overall high-speed growth "Eleventh Five-Year Plan" period and the rate of total energy consumption growth was 6.96%. During the "Twelfth Five-Year Plan" 4 years ago, the average annual increase was 13.8% - higher than during the "Eleventh Five-Year Plan" (6%). This growth momentum prompted the self-sufficiency rate to decrease by 0.68% over the previous year, and 96.5% of the energy depend on external supply, thus energy security being fragile. During the "Thirteenth Five-Year Plan" period, the local government continued to attach great importance to energy conservation work to improve energy efficiency, and conscientiously implement energy saving policies and measures, making the total energy consumption growth momentum significantly inhibited. Although the growth rate of energy consumption has come down, the expansion of the total amount is obvious. From the total energy consumption point of view, the energy consumption appeared a "rapid growth, moderate growth, rapid rise, steady growth" evolution trend.

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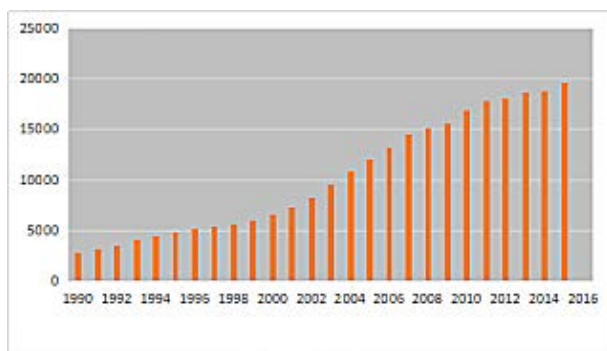


Fig.1. 1990-2016 total amount of energy consumption in Zhejiang (unit: 10,000 tons of standard coal)

Structure of energy consumption analysis

The current energy consumption is mainly coal consumption, oil consumption, natural gas consumption and electricity consumption.

The structure of energy consumption is still dominated by coal, but its proportion shows a declining trend. While the production of coal was declining, self-sufficiency rate is less than 1%, the coal supply basically relies on the transfer from foreign provinces and import. So, the government will take some measures to curb this phenomenon, reducing the use of coal and inhibiting its growth. In the "Eleventh Five-Year Plan" period the use of coal fell by 4.8%, but in the first three years of the "Twelfth Five-Year Plan", the locals introduced a large number of coal-fired power generation stations, making the proportion of coal to decrease by only 1.6%, the average annual decline being 0.5% and slowing down.

So far, the land field has not found yet oil and gas resource, and all oil resources basically rely on external supply. In recent years, refined oil consumption maintained an average annual growth rate of 17.26%. Refined oil consumption reached 25.271 million tons in 2016, by 13.68% over the previous year. Among them are 12.4683 million tons of gasoline, and 7.5649 million tons of diesel. Ratio of diesel to gasoline is 1.64: 1.

Since the beginning of using natural gas from the west to east in 2004, the natural gas market has developed rapidly. In 2016, natural gas consumption reached 8.8 billion cubic meters, by about 12.8% over the previous year. However, the consumption of natural gas is still subject to great restrictions. It also lacks the necessary natural gas spiked facilities and urban reserves of gas sources, affecting natural gas transfer.

Electric power as the most important secondary energy in production and life, the total energy consumption has expanded year by year. Although the intensity of national economic energy

consumption has declined year by year, the decline slowed down year by year, and the power consumption intensity increased year by year. Overall, the energy consumption structure is still dominated by the polluting coal. This poor energy consumption structure has caused serious environmental pollution, high energy cost of products, weak competitiveness and many other issues. In recent years, natural gas, other high-quality energy sources such as solar energy, geothermal energy and other new energy developments continue to increase, improving the proportion of natural gas. Other high-energy and new energy sources will be the future of a long period of energy consumption structure adjustment.

The basic situation of economic development

Over the past 20 years, with the steady growth of total energy consumption, the GDP also showed a good upward trend. GDP reached 428.846 trillion yuan in 2015, which is a 6.70% increase over the previous year. From 1990 to 2015, the GDP of Zhejiang Province increased from 90.469 billion yuan to 42886.49 billion yuan, with an average increase about 13%. By contrasting the GDP of different years, it is clear that from the early nineties to the middle of the twentieth century, the GDP growth rate was relatively fast, nearly four times over a short period of six or seven years. In the late 1990s, the GDP growth rate gradually flattened. After 2000, the GDP growth rate was gradually accelerated in a short period of 15 years it rose from 6,141,303 million yuan to 42886.49 billion yuan, which also reflects the good momentum of development of the economy in the "Eleventh Five-Year Plan" period, "Twelfth Five-Year Plan" period and "Thirteenth Five-Year Plan".

EMPIRICAL ANALYSIS

Data selection and description

In this paper, the energy consumption was assessed from the total energy consumption and energy structure of the data from 1990 to 2015. Economic development was expressed as gross domestic product(Y) obtained by the growing consumption of electricity, and the total amount of energy consumption (E). The proportion of electricity consumption to total consumption represents the energy structure (S).

Unit root test

Since the Granger causality test is sensitive to the smoothness of the sequence, the ADF method was used to test the unit root of each variable. The unit root test is also very sensitive to different lag orders.

Table 1. Results of the Johansen co-integration test

Number of CEs assumed	Eigen values	Eigen value test		Extreme Eigen value test	
		Trend statistics	5% of the critical value	Extreme Eigen value statistics	5% of the critical value
None	0.583482	34.04793	29.79707	21.01979	21.13162
At most 1	0.272240	13.02814	15.49471	7.626803	14.26460
At most 2	0.201528	5.401337	3.841466	5.401337	3.841466

When the ADF test was carried out, the AIC information criterion was used to determine the lag order. The results show that all lnY, lnS, and lnE have unit roots and unstable sequences. They are single-homogeneous and second-order single whole, so the co-integration test requirements are met.

Co-integration test

On the basis of the above tests, we used the Johansen maximum likelihood method to test the covariance of the three variables. Table 1 lists the Johansen test results.

The maximal Eigen value test gave the same conclusion: it rejects the null hypothesis that there is no covariant vector at the 5% significance level, and accepts the hypothesis of covariate vector in the system. The whole test uses the co-integration equation:

$$\ln Y = 0.66933 \ln S + 0.30887 \ln E \quad (1)$$

There is a long-term stable relationship in the model, the elasticity coefficient of lnS to lnY is 0.66933, and the elastic coefficient of lnE is 0.30887, indicating that GDP will grow by 0.66933% if energy structure increases. GDP will grow by 0.30887% for every 1% of energy consumption increase. It can be seen that in the long run, the change of energy structure has more impact on GDP than the impact of energy consumption, which also shows the importance of adjusting and optimizing the energy structure for economic development for a long time.

Granger causality test

In order to verify the direction of the causal relationship of the three variables, this paper used Granger causality to test lnY, lnS and lnE. According to the criteria of determining the lag order, the latter was determined to be 2. We can conclude that it accepted the existence of lnY and lnE two-way causal relationship at the 10% significance level, and lnS is lnY Granger reason. It can be concluded that economic development, energy structure and energy consumption are in a causal relationship indicating that the economic development will also promote the increase in energy consumption. At the same time, the increase in energy consumption changes energy structure, and will also affect economic development.

CONCLUSIONS AND RECOMMENDATIONS

Through the above empirical analysis, the following conclusions may be drawn:

Between Zhejiang economic development, energy structure and energy consumption there exists a causal relationship. Energy structure and energy consumption have a strong impact on the economic development; in turn, the latter can affect energy consumption while the energy structure has a weak impact. Through the co-integration test it was found that the effect of energy structure on GDP is higher than that of economic consumption. Based on the above conclusions, while other conditions remain unchanged, the full supply of energy can be protected if an appropriate speed of sustainable development is maintained. In the long run, it is of great significance to adjust and optimize the energy structure for economic development.

The empirical analysis shows that the sustained growth of Zhejiang economy strongly depends on energy consumption. Energy as a necessary factor of production and strategic material has a significant impact on the development of Zhejiang economy, while coal consumption in energy consumption structure is difficult to change in a long time. Through the above analysis, we give the relevant policy recommendations:

1) To ensure coordinated development of energy and economy, and actively develop a variety of new energy sources we are vigorously transforming the traditional energy industry and actively developing new energy sources, improving the energy industry technological content. As Zhejiang is located in the southeast coastal areas, it has tidal and wind energy reserves. At the same time, it should deal with the sustainable development of the energy industry and resolutely stop all kinds of short-term behaviors.

2) To optimize the energy consumption structure and strive to "clean" direction adjustment, Zhejiang province should actively develop hydropower, optimize the development of coal, focus on the development of nuclear power and vigorously develop natural gas power generation, solar energy, biomass and other renewable energy sources and try to reduce coal in energy consumption. Specific measures can be divided into the following three aspects: coal, oil, and natural gas. Zhejiang province

should jointly promote the development of these resources from the aspects of science, technological development and policy support.

3) To speed up the upgrading of industrial structure, and promote the transformation of economic development because the energy efficiency of different industries is very different. Zhejiang province proportion of secondary industry is as high as 53%, and energy efficiency is better than in the country. This shows that industrial energy utilization is high; on the other hand, it shows that energy-saving potential is very large. If the proportion of the third industry rises while the proportion of the secondary industry is relatively low, it is necessary to control the total energy consumption and improve energy efficiency.

4) To improve the energy reserve system and the ability to deal with emergencies. As Zhejiang has a big economy, energy construction must be able to resist risks, there must be certain strategic material reserves, including both physical and channel aspects. Material reserves are setting up for price factors such as climate change, climate change, boom, social turmoil and so on. According to the prevailing situation, there is a guaranteed bottom line. Channels are mainly reflected in the source and transport, ensuring long-term supply base, railway

safety, and maritime transport. The stability of the province and the overall situation of the country has a very big significance in this aspect.

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REFERENCES

1. E. Sh. Yu, J.Y. Choi, *Journal of Energy and Development*, **10**, 249 (1985).
2. J.W. Liang L. Zhou, Energy Consumption and Economic Growth: Co-integration and Granger Causality Test , 2012 IEEE 19th International Conference on Industrial Engineering and Engineering Management (IE&EM 2012).
3. Q. Zhu, Zh.H. Luo, *Eco-Economy*, **4**, 34 (2015).
4. Ch.X. Zhang, *Special Economic Zone*, **3**, 53 (2009).
5. X.Z. Luo, *Assets and Industries*, **4**, 23 (2007).
6. Q.W. Zhu, *Depth Study*, **8**, 15 (2009).
7. L. Li, G.H. Zhou, Ch.H. Wang, *Economist*, **6**, 50 (2015).
8. Y.X. Ma, *Journal of Northwestern University*, (2009).
9. L.B. Zhang, *Journal of Nanjing University*, (2015).