Energy Consumption in Jiangsu and Its Development Path to Low Emission of Carbon Dioxide Economy

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Abstract This paper is prepared by quoting the data of GDP and energy consumption of industrial enterprises in Jiangsu from 1995 to 2008, of which indexes, including energy consumption, energy consumption structure, together with elasticity coefficient of energy consumption, energy consumption intensity and carbon emission intensity were selected for the analysis of energy consumption and carbon emissions situation in Jiangsu's economic growth. The results showes: (1) Energy consumption continues to grow at an annual rate 10.10%, but the average annual growth rate is of fluctuations, especially in the period of 2002-2005, when its average annual growth rate up to 19.60%, higher than that of GDP by 5.3 percentage points over the same period. (2) Energy consumption is mainly counted by coal, with an annual accounting rate being stabilized in the vicinity of 70%. (3) Apart from elasticity coefficient of energy consumption, energy consumption intensity tends to decrease, but is still higher compared to developed countries. Similarly, these two indicators were obviously rebound in 2002-2005. (4) Carbon emission intensity is not high, but the carbon emission is large, showing average annual growth rate up to 9.73%. It is then concluded: The economic development in the province is more dependent on energy demand. Meanwhile, the rapid growth in energy consumption and the coal-dominated energy consumption leading to a high-carbon situation is highly featured in Jiangsu's economic development. Jiangsu's economic restructuring is expected to transfer as quickly as possible from high-carbon growth to low-carbon development. Combined with actual conditions in the province, the final part of this paper proposes the policy proposals of low-carbon economic development.
Key words Low-carbon economy; Energy consumption; Carbon emissions; New energy industry

1 Introduction

In 2003, British Prime Minister Tony Blair published his famous White Paper entitled, *Our Future Energy: Creating Low-carbon Economy*, and this for the very first time to propose the concept of low-carbon economy. After the development of Bali Road Map in 2007, the concept of low-carbon economy was really expanded from a national scope to the global idea. In recent years, research activities by Chinese scholars have been emerging on low-carbon economy. Based on existing literature, we found that those studies were highlighted on the following aspects: some scholars, including ZHUANG Gui-yang (2005), FU Yun (2008), BAO Jian-qiang (2008), etc., focused on their discussions on such basic questions as what is low-carbon economy, and why we should develop the low-carbon economy[1]-[3]; GUO Yin (2009) and FENG Bi-mei (2010) described the experiences that were obtained from the developed countries in their low-carbon economy[4]-[5]; more scholars, such as BAO Jian-qiang (2008), GUO Yin (2010), FENG Bi-mei (2010), FENG Zhi-jun (2009), conducted their studies that were focused on how to choose development model of low-carbon economy in China[3]-[6].

Viewing from the existing literature, the national research is focused on the macro studies on a low-carbon economy with regard to its content, the basic theory and development, and more highlighted in qualitative research. We believe that low-carbon economy is carried out in a specific spatial scale. But there are quite differences in different regions' economic development, so there certainly are great differences in developing low-carbon economy. In this paper, we took Jiangsu Province as the example, and attempted to combine qualitative and quantitative research on the local low-carbon economic development. Meanwhile, we noted of the assessment presented in 2007 by the Intergovernmental Panel on Climate Change (IPCC), and that increase of greenhouse gases mainly came from burning fossil fuels, with the carbon dioxide emissions accounting for 95.3% of the total carbon emissions. Studies suggest that the proportion has also gone up to 89.5% in Jiangsu. Accordingly, we believe that in low-carbon economic development, energy consumption, carbon emissions, as well as the relationship between them are a matter of concern. Based on the above understanding, this paper was designed in view of indicators, such as energy consumption, energy consumption structure, elasticity coefficient of energy consumption, energy consumption intensity, carbon emission intensity, etc., in attempt to give analysis on the situation of energy consumption and carbon emissions in Jiangsu's economic growth. Based on

the findings, in combination of the province actuality, we put forward the proposals for the local low-carbon economic development.

2 Status of Energy Consumption and Carbon Emissions in Jiangsu's Economic Growth

It is inevitable that a region's economic growth requires a certain amount of energy consumption, both related in input and output. The study on the relationship between economic growth and energy consumption in Jiangsu involves measurement on two indicators: economic growth and energy consumption. In this paper, the indicator of economic growth was expressed by Jiangsu's GDP in the calendar year. Here, energy consumption refers to industrial enterprises' three main energy consumptions, including coal, oil and nature gas. In order to better illustrate the issue, this paper listed the total energy consumption (in addition to the three main energy sources, there were also coke, gasoline, kerosene, diesel and fuel oil). Indicators are derived from *Jiangsu Statistical Yearbook* (1996-2009)[7]. In specific calculations, the year of 1995 was taken as the basis for GDP to be adjusted as comparable prices; energy consumption was converted into standard coal for calculation, in which 1 ton of coal was equivalent to 0.7143 tons of standard coal; 1 ton of crude oil was equivalent to 1.4286 tons of standard coal; 10,000,000 cubic meters gas was equivalent to 121,430 tons of standard coal.

2.1 Energy consumption and its structure of Jiangsu Province

Figure 1 shows the trend of GDP and energy consumption in Jiangsu during 1995-2008, indicating that Jiangsu's economy in the period maintained steady and rapid development, with an average annual growth rate of 12.51% (calculated by the level method, the same below), in which the period of 1995-2001 saw the economic growth rate (11.01%) that was significantly lower than that of 2002-2008 (14.16%). Analysis results also showed that three major energy and total energy consumption presented an average growth rate of 9.67%, 10.10%, respectively, slightly lower than the GDP average growth rate, and suggesting the characteristics of wide fluctuations. Take, the total energy consumption, for example, had a significant increase in its growth rate reached 19.60% during the period 2002-2005, 5.3 percentage points over the GDP growth rate at the same period. In particular, in 2004, energy consumption increased by 24% over the previous year, and higher than GDP growth rate by 10 percentage points in the same year. In the 2006-2008 period, the energy consumption growth slowed down, lower than the same period of GDP growth rate by 6.5, 2.3 and 8.7 percentage points (based on the previous year).

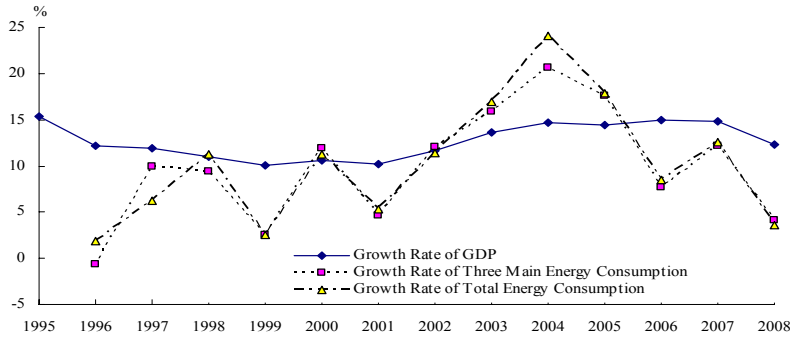

Figure 1 GDP and Energy Consumption in Jiangsu during the Period 1995- 2008

We believe that changes in energy consumption in Jiangsu's economic development are consistent with the GDP proportion of the primary, secondary and tertiary industries, or the industrial-based characteristics. Table 1 shows the detailed description of the three industries structure in Jiangsu during the period 1995-2008. With reference to the proportion of secondary industry, we divided the industrial structure change into two stages: First, a stable stage. During 1995-2002, the proportion of secondary industry in Jiangsu did not change much, roughly near the fluctuation in 51.5%. In the same period, the proportion of primary industry decreased from 16.8% to 10.47% and the proportion of tertiary industry slowly increased from 30.53% to 36.69%. Second, phase of growth. For the period 2003-2008, the secondary industry accounted for a substantial increase than the previous stage in Jiangsu, with the mean of 55.75%. Especially in the period from 2004 to 2006, the figure remained at 56% or more, except for 2007 and 2008 that declined slightly. In the same period, the proportion of primary industry continued to decline, while the tertiary industry had little change. At this phase, accelerated industrialization came along with a very high degree of Jiangsu's economic growth that depended on energy consumption. We

also noted that industry accounted for about 80% of energy consumption in Jiangsu during the period 2000-2008, in which the light and heavy industries took up the proportion of industrial production that changed from 43.20%: 56.80% into 28.1%: 71.9%, that is, the proportion of heavy industry in the eight years increased by 15.1 percentage points. The above figures show that Jiangsu Province has been more and more obviously characterized by heavy industry in recent years. This will inevitably lead to a large demand for energy consumption, and an enormous pressure on the environment in Jiangsu.

Table 1 Evolution of Three Industrial Structures in Jiangsu during the Period 1995-2008

Time	The Primary Industry (%)	The Secondary Industry (%)	The Tertiary Industry (%)
1995	16.80	52.67	30.53
1996	16.47	51.20	32.33
1997	15.51	51.07	33.42
1998	14.54	50.56	34.90
1999	13.48	50.93	35.60
2000	12.26	51.86	35.88
2001	11.57	51.89	36.53
2002	10.47	52.84	36.69
2003	9.34	54.55	36.11
2004	9.12	56.24	34.65
2005	7.98	56.57	35.45
2006	7.14	56.60	36.26
2007	7.06	55.58	37.37
2008	6.93	54.97	38.10
Average	11.33	53.39	35.27

In the period of 1995-2008, energy consumption structure in Jiangsu is indicated as Figure 2. We can see that the energy consumption in Jiangsu had the proportion of coal in the vicinity of 70%, overwhelmingly dominant in that period; oil, accounting for a cumulative decline of 8.5 percentage points, went down significantly; proportion of natural gas increased by 2.8 percentage points. As for the energy consumption in Jiangsu in 2008, coal, oil and natural gas accounted for 69.75%, 15.04% and 2.81%, respectively. Over the same period, coal, oil and natural gas had average of 28.4%, 35.8% and 23.7% in global energy consumption. Clearly, the energy consumption structure is not reasonable in Jiangsu. We believe that the coal-dominated energy consumption structure of Jiangsu is primarily subject to by the China's energy resources.

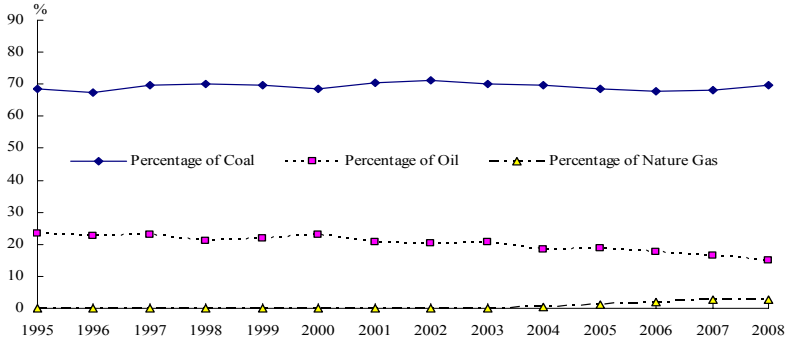

Figure 2 Energy Consumption Structure in Jiangsu during the Period 1995- 2008

2.2 Elasticity coefficient of energy consumption of Jiangsu province

As the international practice, changes in elasticity coefficient of energy consumption are used for comprehensive analysis of the relationship between economic growth and energy consumption for a certain period. Elasticity coefficient of energy consumption refers to the ratio of the growth rate of energy consumption and GDP growth rate, which is generally used to predict a national or regional energy demand. Figure 3 shows the description of the changes in elasticity coefficient of energy consumption of Jiangsu Province during the period 1996-2008. Figure 3 tells us that with the steady economic growth in Jiangsu, elasticity coefficient of energy consumption was greatly volatile during the period 1996- 2008. Here is an example of total elasticity coefficient of energy consumption: the minimum value of 0.16 and the maximum value of 1.63 occurred in 1996 and 2004, respectively, a difference of 1.47 percentage points. Meanwhile, 2001 had a lower elasticity coefficient of energy consumption, which yet increased substantially after 2002. As late as 2005, the coefficient had been maintained high (above 1.0), and even up

to 1.63 in 2004. This shows that over these four years, energy consumption of the province grew faster than economic growth, that is, Jiangsu's economic growth had a high dependence on energy demand, presenting an adverse situation featured with economic development at the cost of high energy consumption. World elasticity coefficient of energy consumption presented the general trend that is gradually decreased, with the overall level of lower than 0.5. Obviously, Jiangsu Province showed that the elasticity coefficient of energy consumption being relatively high, indicating that the development of industrialization in Jiangsu still at the post-industrial era.

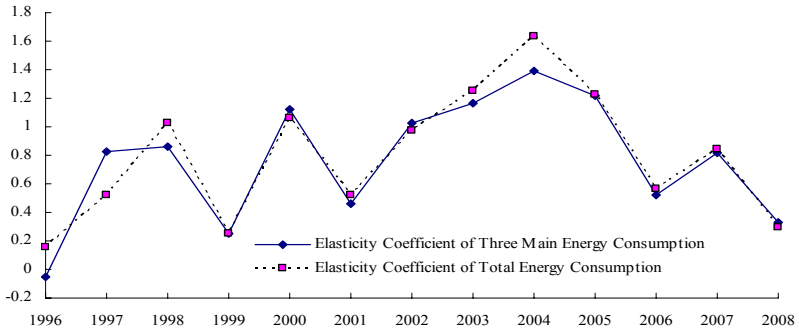

Figure 3 Elasticity Coefficient of Energy Consumption in Jiangsu during the Period 1996- 2008

Note: If the elasticity coefficient of energy consumption is less than 1.0, the energy consumption per unit output value this year will be less than the index in the previous year, then the energy consumption intensity of the current year will decline over the previous year.

We believe that the elasticity coefficient of energy consumption in Jiangsu with the sudden increase in the period 2002-2005 is closely related to speeding up regional industrialization and urbanization process in this phase. First, the rapid growth of investment, where more than 28% annual growth rate of fixed asset investment for four consecutive years, and even up to 38.6% in 2003. Second, the marked increase in proportion of heavy industry, including metallurgy, petrochemical, power, building materials and paper industries, etc., accounted for more than 70% of the whole manufacturing industries. Rapid expansion of high-energy-consumption industries was accompanied by substantial growth of high-energy-consumption production, resulting in energy consumption growth significantly faster than that of GDP. After 2005, changes in the macroeconomic environment came along with the apparent effect of the national macro-control measures. Jiangsu has slowed down the pace of development of heavy industry, while high-energy-consumption industry is under control, so the elasticity coefficient of energy consumption to be decreased significantly (below 1.0).

2.3 Energy consumption intensity of Jiangsu province

Energy consumption intensity is the unit GDP involving amount of energy invested, also known as the unit GDP energy consumption. Energy consumption intensity is the main indicator that reflects the energy efficiency. Figure 4 illustrates the change in the energy consumption intensity in Jiangsu during the period 1995-2008. According to Figure 4, in the period from 1995 to 2008 energy consumption intensity of the province saw a decline in general, but there was a rebound sign during the period 2003-2007. Here again we give the example of total energy consumption intensity: the index value decreased from 1.0606 tce/10,000 RMB in 1995 to 0.8185 tce/10,000 RMB in 2002, and rapidly

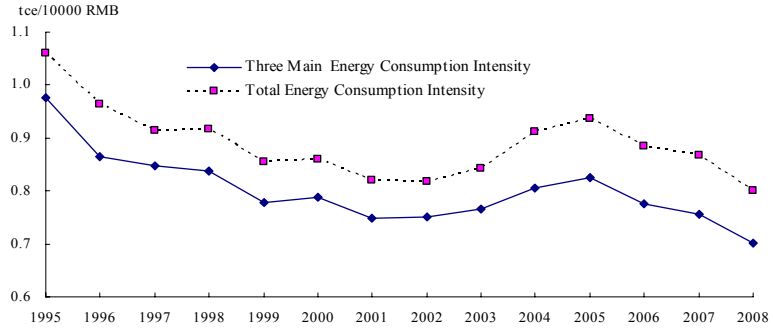

Figure 4 Energy Consumption Intensity in Jiangsu during the Period 1995-2008

increased to 0.9378 tce/10,000 RMB in 2005 within two years. After 2006, the index value decreased rapidly, and fell to the lowest value of 0.8003tce/10,000 RMB in 2008, lower than the national average value by 27%. Despite the energy consumption intensity in Jiangsu ranked at the forefront in the country, there is still a wide gap compared with developed countries.

We believe that the major factors leading to higher energy consumption intensity in Jiangsu lie in the post-industrial era, where heavy industry occupies a significant portion, along with higher proportion of high-energy- consumption industry, low levels of energy technologies and energy efficiency. During 2003-2005, there was a substantial increase in energy consumption intensity in the province for three consecutive years, closely associated with this phase of heavy industry, especially high-energy-consumption industries for sustained high growth in manufacture. This once again illustrated the fact that Jiangsu's economic development was supported by high-energy-consumption, and the creation of unit GDP need to consume more energy in this period. According to the "Outline" of China's "Eleventh Five-Year Plan", indicating the binding target of unit GDP energy consumption to be reduced by 20%, Jiangsu issued a series of important policy measures to promote energy saving, and speeding up the related work since 2006. As a result, the trend in unit GDP energy consumption of the province that rose rapidly has been basically brought under control.

2.4 Carbon emission intensity of Jiangsu province

Carbon emission intensity refers to the emissions of carbon dioxide per unit GDP. Subject to data constraints, this paper only provided the estimates of carbon emissions of the three main energy consumptions: coal, oil and natural gas. In the specific calculation, the carbon emission factor was determined by reference of the research results from DOE, Japan Energy Economy Research Institute, Project of Climate Change sponsored by Ministry of Science and Technology, XU Guo-quan and other research institutions and scholars working on carbon emissions [8], with their mean value taken as the carbon emission factor in Jiangsu, as shown in Table 2.

Table 2 Carbon Emission Factor of Energy Consumption in Jiangsu's Economic Development

Data Source	Coal	Oil	Nature Gas
DOE/EIA	0.7020	0.4780	0.3890
Japan Institute of Energy Economics	0.7560	0.5860	0.4490
The Climate Change Project of Chinese Ministry of Science and Technology	0.7260	0.5830	0.4090
Xu Guoquan	0.7476	0.5825	0.4435
Average	0.7329	0.5574	0.4226

Figure 5 shows the results of carbon emission intensity in Jiangsu during the period 1995-2008, and we found: on the one hand, both carbon emissions and per capita carbon emissions had rapid growth, showing the average annual growth rates of 9.73%, 9.02%, respectively. On the other hand, carbon emission intensity tended to decrease, but its change showed significant stage characteristics. The first phase had a rapid decline. In the period 1995-2001, Jiangsu's carbon emission intensity had decline from 0.7661 tons/10,000 RMB to 0.5914 tons/10,000 RMB, 4.22% annually. The second is the recovery stage. During 2002-2005, Jiangsu's carbon emission intensity was picked up from 0.5940 tons/10,000 RMB to 0.6521 tons/10,000 RMB, an average annual increase of 3.16%. The third is the decline stage. After 2006, the province had a decline in carbon emission intensity, with the lowest value of 0.5537 tons/10,000 RMB in 2008, an average annual decline of 4.72%. From national and international

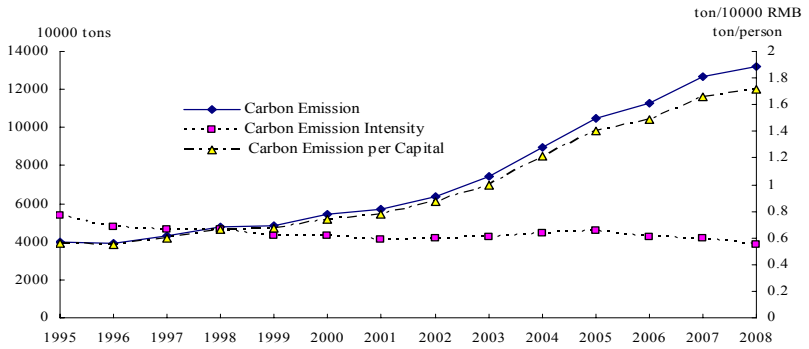

Figure 5 Carbon Emission Intensity in Jiangsu from 1995 to 2008

comparisons, Jiangsu's carbon emission intensity was not high. But the large amount of carbon emissions for rapid growth was worsened by per capita carbon emissions that also increased rapidly.

We believe that in the period of analysis, the basic characteristics of carbon emissions in Jiangsu is closely related to economic development, energy consumption structure and the change of energy consumption. First of all, Jiangsu is China's economically developed areas. In 2008, the region's GDP accounted for 10.08% of the total GDP, and its GDP had an average annual growth rate of 12.51% during the period 1995-2008. The rapid economic growth in the province naturally led to higher energy consumption, while energy consumption was precisely the subject of carbon emissions, which accounted for more than 90% of the total carbon emissions, and then bringing regional sustainable increase of carbon emission. Second, the coal-dominated energy consumption structure of the province also stimulated the growth of carbon emissions. This is because the carbon emission intensity of coal is higher than other fossil fuels. The carbon dioxide released from burning unit mass of coal was close to twice that of natural gas. Third, during the 2002-2005, the province in the industrialization process promoted the rapid increase in energy consumption intensity of this phase, which led directly to the increase of carbon emission intensity. After 2006, the slowdown in the carbon emission intensity of the province was mainly from the government's efforts in macro-control.

3 Jiangsu's Development Path to Low-carbon Economy

High-speed economic development and the industrial structure dominated by the secondary industry in the region lead to a high demand for energy consumption, while carbon dioxide emission from energy consumption is mainly responsible for carbon emissions. Particularly in Jiangsu, the local carbon emission is exacerbated by the coal-dominated energy consumption structure, which has also brought pressure on the environment that can not be ignored. Based on the actuality, we offered the following important ways to promote low-carbon economic development in Jiangsu.

3.1 Adjusting the industrial structure to build the modern industrial system

Currently, Jiangsu Province is in the stage of economic development that is characterized by the heavy industry, and difficult to be changed in the short term. It is recommended that efforts in three aspects should be combined to improve the industry structure in high-carbon economic development model: The first is limiting high-carbon industry. The industry structure and product mix should be both adjusted to gradually reduce the proportion of high-energy-consumption industry, and eliminate backward production capacity and technologies, structurally promoting low-carbon economy development. The second is to upgrade traditional industries to high-end chain. And as a manufacturing province in the open economy model, "Made in Jiangsu" is still in the low-end of the industrial chain. Whether to undertake international industrial transfer, or to produce export products, mostly are in high-carbon production status. Therefore, the traditional industries in Jiangsu should be sped up for extending to both ends of the industrial chain. On the one hand, extending to the front, with the objective of attaining independent intellectual property rights from design and R&D. on the other hand, it can extend to the back-end, aiming to form a brand and sales network, so as to take hold of high-end links of industry to improve traditional industries development in Jiangsu. Third, vigorously develop modern services. Currently, the share of services industry is less than 40% of GDP in Jiangsu, accounting approximately for half of the developed countries. To promote industrial upgrading of the province, appropriate financial policy should be adopted for support of modern service industry, especially the financial, logistics, tourism, culture, information and technology services and other low-carbon industries featured with lower energy consumption, less pollution and more employment opportunities to play a greater role in Jiangsu's economic growth.

3.2 Developing new energy industries to improve the economic efficiency of energy

We believe that Jiangsu has limited space for reducing carbon emission intensity, and the focus on energy conservation in the future should be placed on the development of new energy sources, and their conversion, application and industrialization. Jiangsu has a leading edge of new energy industries in the country, but still not superior in low-carbon. In addition to manufacturing standards that need to be improved, there are some issues in the transformation and application of new energy industries, such as the electricity price is too high for the new energy coming to grid (photovoltaic solar energy has the existing rate of 1.70 RMB per kWh, and 0.61 RMB per kWh for wind power, while coal is rated at 0.38 RMB); wind power is difficult to achieve stable grid access etc. However, the key to raise the low-carbon contribution rate of new energy precisely lies in the conversion and application of new energy industrial advantages, and this point has become the consensus of European and American

countries. These countries also have taken the development and application of new energy sources as an important entry point that leads to future economic development. In Europe, the development of renewable energy has become one of the important growth points to create jobs, and the renewable energy company hired the number of employees that is 2-10 times of that in coal companies. Britain proposed that by 2020, 40% of the electricity would come from clean energy, including solar, wind energy. Denmark, Germany, Spain and other European countries are leading the world in wind power development and utilization. Data showed that Denmark has enjoyed wind power that reached 22% of the total electricity consumption, in which a considerable part of their green power, except for domestic use, are exported to Norway. Germany's wind power installed capacity accounted for more than 1/3 of the world, in which in 2008, wind power capacity reached 8% of the total.

How to achieve the conversion and application of new energy industrial advantages of Jiangsu? We believe that it is particularly important for policy guidance and promotion to be supported by clearing away the barriers of professional technology. First, the new energy development plan should be developed based on existing policies as soon as possible to clear specific goals and measures. Meanwhile, more efforts should be given to support the research and development in the industrialization of new energy, while increasing solar, wind, biomass and other new energy sources as to their proportions in the whole energy structure. Second, the increased R&D investment to reduce costs through technological advances in new energy industries is targeted at the sized industrialization, increasing the proportion of new energy industries in the whole industrial structure. Third, financial subsidies, tax incentives and other economic levers can also be used to promote new energy industries in their promotion and application.

3.3 Promoting low-carbon technology innovation to improve the technical efficiency of energy

Variety of low-carbon technologies are many, and can generally be attributed to energy efficiency promoting technology, energy saving technology, renewable energy and new energy technologies, greenhouse gas reduction technology, etc. [9] Low-carbon technology innovation should be based for improving the input-output efficiency and the technical efficiency of energy use, and further to change the economic development from relying on resources consumption into innovation-driven as the fundamental requirement in the province. Combined with the specific situation of Jiangsu Province, we believe that international cooperation and R&D investment is an important way to promote low-carbon technology innovation.

First, establish international cooperation to improve the R&D capabilities of low-carbon technology. Jiangsu now has some basis for low-carbon technologies, but that's not superiority. The real problems for various industries on low-carbon development are basically focused on technical support. Low-carbon technology development mainly depends on two types of channels, that is, independent research and development and the introduction of foreign advanced technology. Affected by many factors, developed countries often have reservations to developing countries and regions in the transfer of technologies, including low-carbon technology. Therefore, in Jiangsu, international cooperation is recommended to absorb the advanced experience of foreign countries at this stage, thus improving low-carbon technology R&D capabilities.

Second, increase R&D investment for low-carbon technology. Low-carbon technology requires substantial manpower and funding support for independent research and development, which involves increased capital investment to provide sustained financial support. In 2009, Jiangsu had its R&D investment that reached 68 billion RMB, accounting for 2.0% of GDP, of which 83% came from business investment, with its regional innovation for the first time ranked first in the country. However, there is still a wide gap compared with the United States, Japan and other developed countries, which have 4% of the R&D investment proportion. R&D investments are especially inadequate from the perspective of energy technologies. In 2009, Jiangsu energy R&D investment accounted for 8.58% of the total R & D investment, about 0.171% of GDP, while Japan accounted for 18.62% and 0.74%, respectively [10].

Third, speed up energy-saving technological innovation. Research institutes and enterprises can be sources of assistance in the development of advanced energy saving technologies and efficient energy saving equipment, while the introduction of competition mechanism should be combined with the implementation of market-oriented operation, continued to promote and accelerate the development of energy saving technology, and its demonstration, promotion and the innovation of energy saving way. In 2009, energy saving R&D investment was less than 2% of corporate energy R&D spending in Jiangsu. Therefore, the provincial government should give financial support to the energy saving technology

projects exposed to higher investments and higher risks, and more efforts should be made on the major energy saving technology development and industrialization.

4 Conclusions

Analysis was made on Jiangsu's economic growth with respect to energy consumption, energy consumption structure as well as elasticity coefficient of energy consumption, energy consumption intensity and carbon emission intensity during the period 1995-2008. The results show: First, the annual growth rate of energy consumption was slightly lower than that of GDP. Growth rate of energy consumption was in a volatile state in the analysis period. It is noteworthy that the index increased significantly during the period 2002-2005, and had total energy consumption growth rate of 19.60%, exceeding the GDP growth by 5.3 percentage points over the same period. The second is long-standing dominance of coal in energy consumption, accounting for up to an average 69.27%, and oil proportion decreased obviously, with natural gas accounting increased slightly. Third, the elasticity coefficient of energy consumption and energy consumption intensity tended to decrease, but still high, and the rebound sign was found significantly during the period 2002-2005. Fourth, despite the lower carbon emission intensity, carbon emissions was growing rapidly, from 39,496,600 tons in 1995 up to 132, 122,300 tons in 2008, average annual growth of 9.73%.

This study suggests that there are distinct characteristics of high-carbonization that can be found in Jiangsu's economic development, which is decided by many factors. With rapid economic growth in the province, the industrial structure dominated by the secondary industry will inevitably lead to higher energy consumption, while energy consumption growth and the coal-dominated energy consumption will promote the continued growth of carbon emissions. During 2002-2005, Jiangsu industrialization and urbanization process was accelerated to enable rapid growth of fixed asset investment and a significantly increased proportion of heavy industry. This is the main reason leading to increased energy consumption that was significantly faster than GDP growth in this phase. Combined with the actual conditions of the province, industrial structure restructuring, new energy industry development as well as low-carbon technology innovations are combined to make an important way for the changes of economic development pattern in the province to achieve a low-carbon economy.

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