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Timing Sequence Evolution, Influencing Factors and Control Approaches to China's Gross Energy Consumption

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Abstract

Confronted by the finite limits of its natural resources and damage to its ecosystem caused by its high level of energy consumption, China is taking the initiative in developing self-restrained. In early 2013, the Chinese government announced clear and specific quantitative targets for the control of gross energy consumption. This could bring gross energy consumption of coal equivalent to less than 4 billion tons by 2015. It would also demonstrate the Chinese government's promotion of a viable ecological future. Despite the variable growth rate in China's energy consumption in the past, over the last 30 years, the gross energy consumption has continued to grow exponentially and China now consumes more energy than any other nation. China's energy consumption has been influenced most significantly by macro-economic growth, the development of industrial structure, residents' consumption structure and urbanization. The mission to control gross energy consumption is going to be an arduous one. In order to achieve its targets, China should establish the allocation and implementation mechanism of control targets for gross energy consumption, implement carbon emission trading, promote policies on industrial transformation and low-carbon society construction, etc.

Key words: Gross energy consumption; Influencing factors; Control approaches

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INTRODUCTION

China's current economic and social development is facing tight resource constraints, severe environmental pollution, such as badly deteriorating air quality, and grim ecosystem degradation. In the first six months of 2013, China has experienced a wide range of fog haze, covering the North China Plain, Huang Huai, Jiang Huai, Jianghan, Jiangnan, and the northern regions of Southern China. The affected area accounts for about 1/4 of the land, and has affected a population of about 600 million people.[1] The chief cause of this poor air quality is the enormous energy consumption required by China's rapid economic growth which has pushed the bearing capacity of the environment and its natural resources to the limit.

In recent years, the Chinese government has strengthened the energy conservation and encouraged consumption reduction, and has achieved some success in this. During the "Eleventh Five-Year" period (2006-2010), China's energy consumption per unit GDP fell by 19.1%, while the world average level over the same period was unchanged. Consumption for the developed countries named in the "Kyoto Protocol", Annex I, declined by only 6.4%. However, due to China's rapid economic growth, and hence its large gross energy consumption, its fast-growing gross level of consumption is still difficult to reverse. During the "Eleventh Five-Year" period (2006-2010), China's GDP grew by 70.0%, and its annual average growth rate was 11.2%, despite a greater decline in energy consumption per unit GDP. So the gross energy consumption went up from 2.36 billion tons of coal equivalent to 3.25 billion tons of coal equivalent, an increase of 37.3%. As the proportion of

[1] National Development and Reform Commission (NDRC), July 10, 2013. The first half of 2013 energy conservation emission reduction analysis. Retrieved from http://www.sdpc.gov.cn/jjxsfx/t20130710_549549.htm

non-fossil energy sources has grown, the increase in CO_2 emissions in China has become lower than the increase in energy consumption, though CO_2 has still increased by 33.6%. From 2005 to 2010, the world's CO_2 emissions increased by 3.089 billion tons, of which 1.837 billion tons was China's, thus accounting for 60% of the gross. Understandably, China is facing rising international pressure to cooperate in achieving a reduction in CO_2 emissions (He, 2013).

To this end, China has proposed a "reasonable control of gross energy consumption, strict energy use management, acceleration of the establishment of an energy development plan, specific targets for gross control, and an allocation and implementation mechanism" in its Outline of National "Twelfth Five-Year Plan" promulgated in 2011.[2] This is the first time the Chinese government has referred to gross energy consumption in national development planning. The transformation of China's economic development mode demands a shift from the control of energy consumption intensity to the control of gross energy consumption. But this is also a shift made inevitable by the need to respond to climate change, and therefore to reduce emissions.

In the early 2013, the Chinese government issued its "Twelfth Five-Year' Plan for Energy Development", which proposed controlling both energy consumption intensity and gross energy consumption during the "Twelfth Five-Year" period (2011-2015). By 2015, gross energy consumption should be 4 billion tons of coal equivalent, while gross electricity consumption should be 6.15 trillion kwh. So energy consumption per unit GDP will have declined 16% from its level in 2010. The Chinese government had placed control requirements on energy conservation and consumption reduction, as well as energy consumption intensity per unit GDP. And the proposal to control both gross energy consumption and gross electricity consumption highlights the Chinese government's determination to address the problem.

From the control of energy consumption intensity to the control of gross energy consumption demonstrates the progress of China's energy policy, and this is strategically significant in pointing to China's achievement of a sustainable energy supply, and its development of both the economic and ecological environment. The "Twelfth Five-Year Plan" also requires China to speed up the transformation of its economic development mode, and to optimize its energy supply-demand management. This article will set out the timing sequence evolution of China's gross energy consumption, study the factors that have influenced gross energy consumption growth, and propose approaches for effective control, according to our analysis.

1. TIMING SEQUENCE EVOLUTION OF CHINA'S GROSS ENERGY CONSUMPTION

Over the last 30 years, China's economy has developed rapidly and accomplished much. However, the price of this economic growth has been high levels of energy consumption, the continued growth of gross energy consumption, and low energy efficiency. 2010 is the last year of China's "Eleventh Five-Year" Plan; according to the accounting data from China's National Bureau of Statistics, in 2010 China's gross energy consumption was 3.25 billion tons of coal equivalent (which is equivalent to approximately 2.275 billion tons of oil equivalent). There is nothing special about this number at a glance, but it does contain a hidden message: China's energy consumption is off track.

The *National Long-Term Energy Planning* statement of 2004 set a target "gross energy consumption in 2020 is 3 billion tons of coal equivalent". So this target figure has been exceeded ten years early. At the same time energy consumption has also greatly exceeded the planning target of gross energy consumption in the "National 'Eleventh Five-Year' Specialized Plan for Energy" in 2007, according to which, China's gross energy consumption should have been controlled at 2.7 billion tons of coal equivalent in 2010.

As early as 2002 China's energy consumption was ranked second only to the United States. However, in 2010, the International Energy Agency (IEA) claimed in its annual report (WEO-2010) that China's energy consumption in 2009, which it put at 2.25 billion tons of oil equivalent, had surpassed the 2.17 billion tons of the United States. This meant that for the first time China became the largest energy consuming country in the world,[3] a position that the Chinese government was unwilling to accept. It is a ranking that can only make negotiation over climate change harder. Chinese officials have denied the conclusions of the IEA's report, pointing instead to the data published by China's National Bureau of Statistics. This shows that China's gross energy consumption in 2009 was 2.146 billion tons of oil equivalent, as against the United States which consumed 2.382 billion tons of oil equivalent in the same year (according to data released by the U.S. Energy Information Administration). If these figures are correct, then the U.S. still held pole position as top energy consumer in 2009.

[2] China's "Twelfth Five-Year Plan" for National Economic and Social Development. Retrieved from http://www.gov.cn/2011lh/content_1825838.htm

[3] IEA, World Energy Outlook 2010 Edition. Retrieved from http://www.worldenergyoutlook.org/publications/weo-2010/

But the IEA explained that because China's energy consumption statistics did not include the traditional fuel wood used in rural areas, China's data for gross energy consumption had a 4%-5% error, and the true figure was higher. The IEA has continued to insist on its figures, and, since the release of the Sino-US energy consumption data in 2010, the Chinese government has continued to refute them.

In addition to the IEA, another authoritative energy statistics report in the energy economy sector, "BP Statistical Review of World Energy 2011", showed that China had become the world's biggest energy consumer in 2010, taking over from the United States. In 2010, China's primary energy consumption was 2.432 billion tons of oil equivalent, an increase of 11.2%, which accounted for 20.3% of the world's gross energy consumption. America's primary energy consumption was 2.286 billion tons of oil equivalent in the same year, an increase of 3.7%, which accounted for 19.0% of the world's gross energy consumption.[4]

According to the data in the "BP Statistical Review of World Energy 2012", in 2011 China's primary energy consumption had risen to 2.613 billion tons of oil equivalent, an increase of 8.8%, accounting for 21.3% of the world's gross energy consumption; while the U.S. consumed 2.269 billion tons of oil equivalent, a fall of 0.4%, so accounting for 18.5% of the world's gross energy consumption. So since 2010, China has continued to outpace the United States and kept its first place ranking in the world.[5]

Despite such high consumption levels, China's energy efficiency is still low, and energy consumption intensity remains high. In 2010, China's GDP surpassed Japan's for the first time and China became the world's second largest economy. However, though China's GDP only exceeded Japan's by about $40 million, Japan's gross energy consumption in 2010 (only 0.50 billion tons of oil equivalent), was about 1/5 of China's. In 2010, the data for GDP of the U.S., China, Japan and Germany were $14.60 trillion, $5.84 trillion, $5.40 trillion, and $3.31trillion respectively. Gross energy consumption in each of the four countries was, 2.286 billion tons of oil equivalent, 2.432 billion tons of oil equivalent, 0.50 billion tons of oil equivalent, and 0.32 billion tons of oil equivalent respectively. The data for GDP, gross energy consumption and energy consumption of oil equivalent per ten thousand dollars of the four countries are displayed in Figure 1.

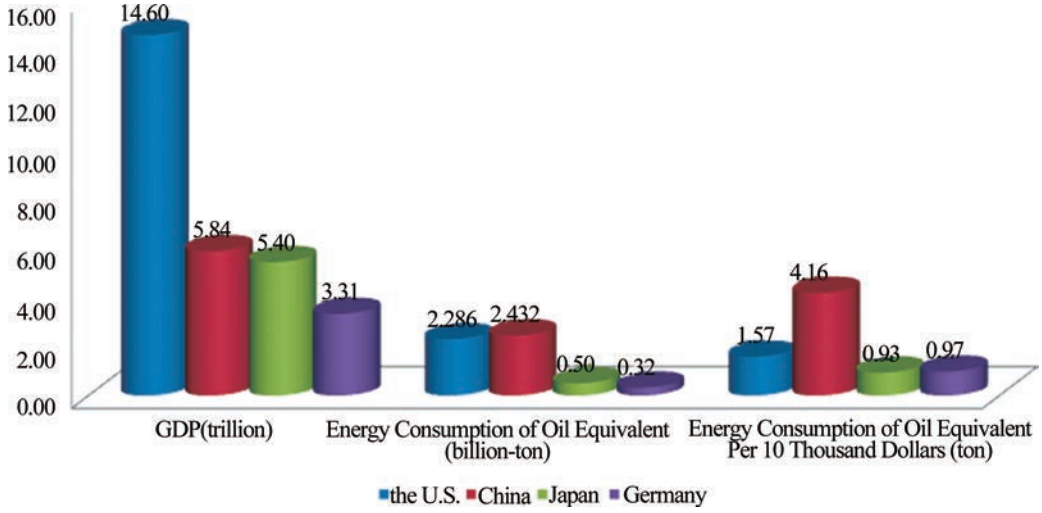

Figure 1
Gross Energy Consumption Contrasted With GDP for the U.S., China, Japan and Germany in 2010

In 2011, the data for GDP of the U.S., China, Japan and Germany were $15.06 trillion, $6.99 trillion, $5.86 trillion, and $3.63 trillion respectively. The data for gross energy consumption in the four countries were 2.269 billion tons of oil equivalent, 2.613 billion tons of oil equivalent, 0.477 billion tons of oil equivalent, 0.306 billion tons of oil equivalent respectively. The data for GDP, gross energy consumption and energy consumption of oil equivalent per ten thousand dollars of the four countries are displayed in Figure 2.

[4] BP Statistical Review of World Energy 2011. Retrieved from http://www.bp.com/multipleimagesection.do?categoryId=4738&contentId=7046865

[5] BP Statistical Review of World Energy 2012. Retrieved from http://www.bp.com/multipleimagesection.do?categoryId=4738&contentId=7046865

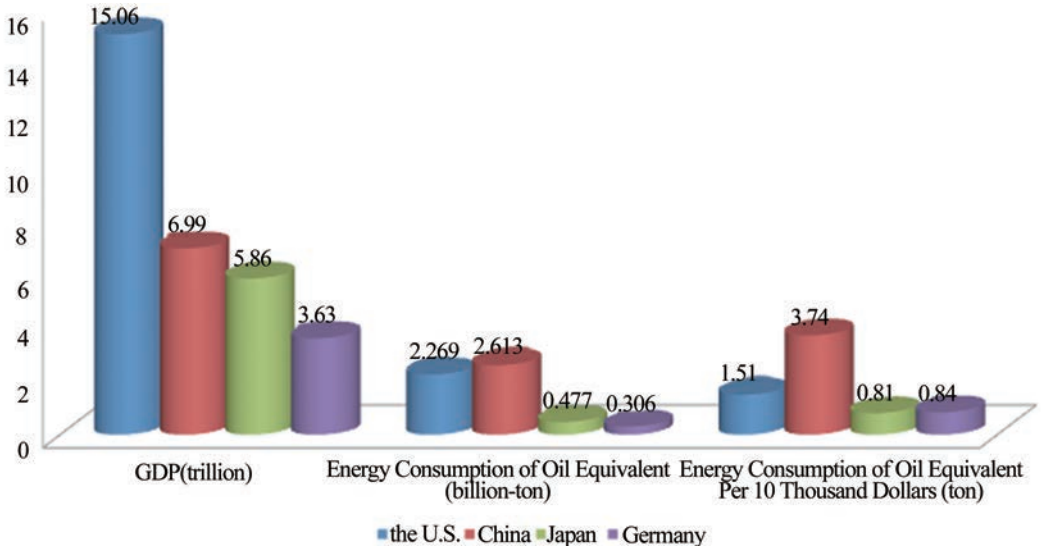

Figure 2
Gross Energy Consumption Contrasted With GDP for the U.S., China, Japan and Germany in 2011[6]

One interesting phenomenon is that in 2011 only China saw an increase in both GDP and gross energy consumption. In the U.S., Japan and Germany GDP increased, but gross energy consumption declined (see Figure 3). In 2012 the world economy went into recession. As a result, the GDP of the U.S. and Japan barely increased at all, and Germany's GDP decreased slightly, while each country's gross energy consumption also remained fairly static. By contrast, China saw an increase in both GDP and gross energy consumption.

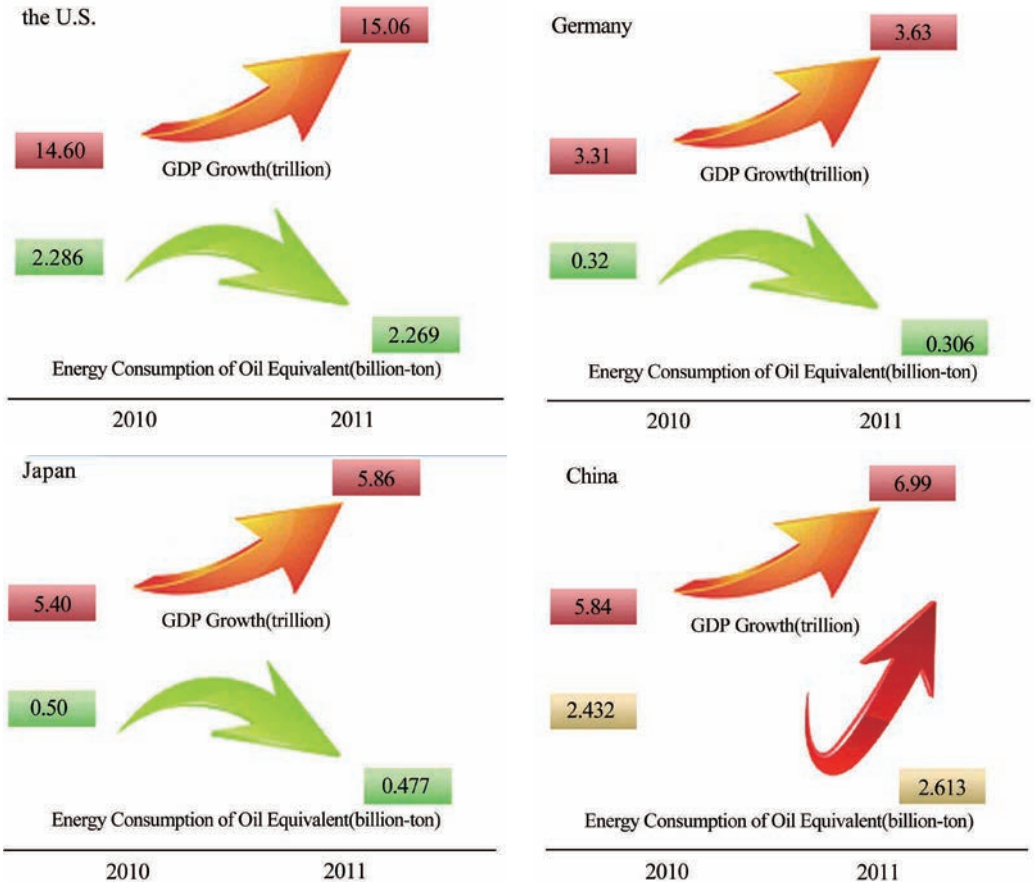

Figure 3
Gross Energy Consumption Contrasted With GDP for the U.S., Germany, Japan and China Between 2010 and 2011

[6] Energy consumption data in Figure 1, Figure 2 were collected from BP Statistical Review of World Energy 2011 and BP Statistical Review of World Energy 2012 report.

2011 was the first year of China's "Twelfth Five-Year Plan" and according to the data from China's National Bureau of Statistics, gross energy consumption was 3.48 billion tons of coal equivalent (about 2.436 billion tons of oil equivalent). This shows that gross energy consumption had increased by 0.23 billion tons of coal equivalent from the previous year, or 7%, which was the largest increment in the last four years. In February 2013, China's National Bureau of Statistics released figures for China's gross energy consumption in 2012. The initial accounting showed 3.62 billion tons of coal equivalent, an increase of 3.9% over the previous year.

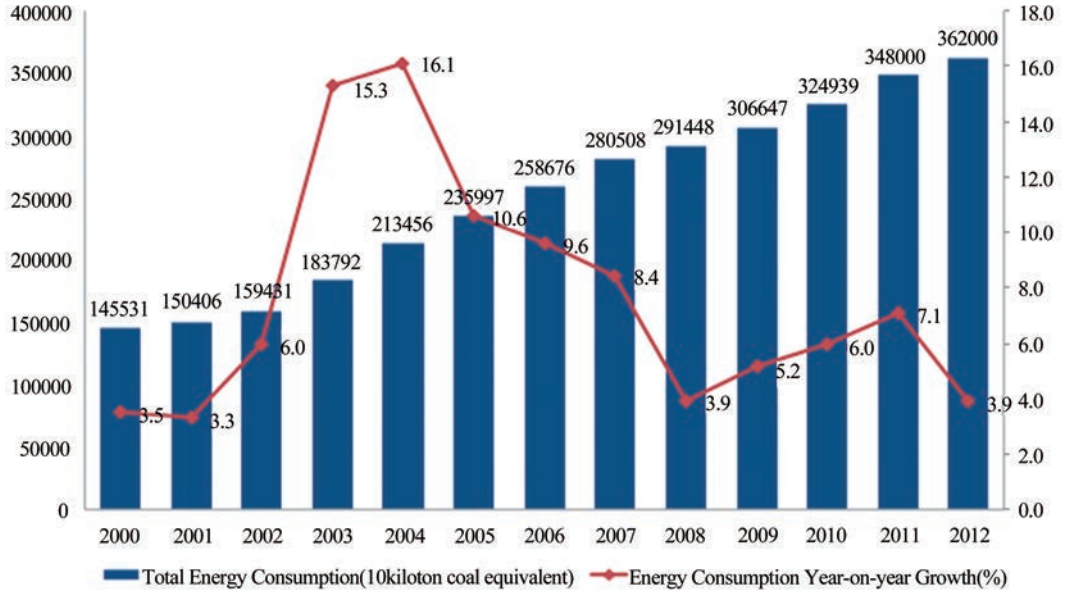

Figure 4
Growth Figure Showing China's Gross Energy Consumption From 2000 to 2012

From Figure 4, we can see that since 2000, although the growth rate of China's energy consumption has varied during those years, gross energy consumption is still growing and exceeding the planned rates. In January 2013, the Chinese government issued the "'Twelfth Five-Year Plan' for Energy Development" which stated:

> China will implement dual control on energy consumption intensity and gross energy consumption. By 2015, the gross energy consumption will be 4 billion tons of coal equivalent, energy consumption per unit GDP will decrease by 16% than that of the 2010 level.

This means that in the next three years, China's gross energy consumption can grow by only 0.38 billion tons of coal equivalent, with an average annual growth rate of only 3.38%: a formidably difficult target to achieve.

Because of the recession in the world economy and the change of Chinese government, China had a lower economic growth rate in 2012 than in any of the previous ten years, while its energy consumption showed a year-on-year increase of 3.9%, the lowest rate of increase in the last ten years. The same year-on-year growth rate appeared once in 2008 because of the world financial crisis, which resulting in China's economy to slow down.

While the year 2012 shows the loosest relationship between energy supply and demand of any in the last ten years, China's gross energy consumption still rose by 0.14 billion tons of coal equivalent from that in 2011. This demonstrates how hard it will be to accomplish the control target of 3.38% average annual growth rate over the next three years. If we review the Chinese political cycle for decades, we can see that there are always good years with a growing economy after a change of government. However, even if the economy grows steadily over the next few years, the level of gross energy consumption is still likely to be far too high, meaning that the control target of 2015 gross energy consumption will still be hard to achieve.

Control of gross energy consumption is the broad focus of China's "Twelfth Five-Year Plan" and its further energy policies. The government's determination to control gross energy consumption is evident in the shift in language used between Plans. "Reasonable control of gross energy consumption" proposed in the Chinese government's "Outline of the 'Twelfth Five-Year Plan' for National Economic and Social Development" changes to the "control of gross energy consumption" proposed in the 18th CPC (Communist Party of China) National Congress report. From "reasonable control" to "Control", showing Chinese government's determination to control the gross energy consumption and their increasing urgency. What is clear is that the key concerns of the Chinese government's gross energy consumption control are now to analyze the influencing factors of gross energy consumption; to develop policies and measures on gross energy consumption control; and to guide Chinese local governments at all levels towards accomplishing the control targets efficiently.

2. INFLUENCING FACTORS OF CHINA'S GROSS ENERGY CONSUMPTION

2.1 Macro-Economic Growth

Energy consumption secures the steady growth of the Chinese economy, while the rapid growth of China's macro-economics is the main driver of the rapid growth in the rate of energy consumption. In the past twenty years, China's economy has sustained rapid growth, which has meant an increasing demand for electricity, leading to the sustained growth of gross energy consumption. According to the data from the *China Statistical Yearbook 2011*, from 2000 to 2010 China's annual GDP growth rate was greater than or equal to 10%, and its energy elasticity coefficient[7] was greater than 0.58, reaching its highest levels in 2003 and 2004 when it rose to 1.43 and 1.60 respectively. The exceptions were in 2001, 2002 and 2008 when the GDP annual growth rates were 8.4%, 8.3% and 9.6% respectively, but their energy elasticity coefficients were 0.42, 0.40 and 0.41 respectively. From 2000 to 2005 and from 2005 to 2010, China's energy elasticity coefficient was 0.76 and 0.55. However according to the data from the IEA, the energy elasticity coefficient in India and Brazil (the countries experiencing comparable economic growth to China) during these two periods were 0.44/ 0.77, and 0.77/ 0.73 respectively (China Petroleum News, 2012). So China's energy elasticity coefficient was significantly higher than those in the developed countries, but was not significantly different from these other developing countries.

Energy is a vital component in the creation of macro-economic growth, so gross energy control will have a significant impact on GDP growth. This means that the control of energy consumption will restrain economic development, and local governments within China may take a negative attitude towards the control of gross energy consumption in their effort to protect GDP growth. In the past ten years, the speed of economic development in Chinese provinces has exceeded the original goals set by central government. China's local government development plan shows that local GDP growth in the "Twelfth Five-Year" period (2011-2015) is expected to sustain the high rate of increase from the previous period ("Eleventh Five-Year" period 2006-2010). Every single region in the country has experienced GDP growth in line with or greater than the government's development goal of 7% (as set out in the "Outline of the 'Twelfth Five-Year Plan'"). According to the local "Twelfth Five-Year Plan", China's average annual GDP growth rate will reach 10% or more, 3% higher than the 7% goal. This makes it difficult to control gross energy consumption efficiently, since the level of consumption is calculated on the basis of a lower rate of economic growth. So effective support of local governments in their efforts to constrain their regional economic growth rate will be vital if China is to achieve gross energy consumption control.

2.2 The Industrial Structure

Industrial structure determines the energy consumption structure, thereby it has affected the gross energy consumption. Different industries consume different amounts of energy. If industries with a higher energy demand account for a large proportion of the national economy and increase rapidly, then energy consumption will also be increased rapidly (Guo, Li, & Tan, 2007).

Primary industry is mainly agricultural and therefore mostly labor-intensive rather than energy-intensive. Agricultural production activities rely mainly on labor input. This labor is mostly simple manual labor which requires a low level of energy consumption. Secondary industry, however, is essentially capital-intensive. The main production factor is capital investment, and production activities are mostly machine-based, with costly equipment, more complex labor functions, a complicated production process, and a higher level of operational energy consumption. The steel and petrochemical industries are two of those with the highest energy consumption in secondary industry, their average annual energy consumption taking up a large proportion of the whole. Tertiary industry is both labor-intensive and capital-intensive but needing fewer units of energy consumption—basically an industry that has no high temperature, high pressure, cryogenic, thermal fusion, etc. requirement. Energy consumption is only an auxiliary condition for any production or service activity.

Looking at industrial energy consumption at present, primary industry in China accounts for about 4% of energy consumption and contributes less than 10% of GDP. This is because agricultural production in China lags behind industrial production (National Bureau of Statistics of China, 2012).[8] Chinese secondary industry has made a 50% contribution to GDP, but consumes about 70% of energy; by contrast, the Chinese tertiary industry accounts for more than 40% of GDP, but consumes only about 15% of the energy. This indicates that the tertiary industry not only satisfies the requirement of energy conservation and consumption reduction, but also fits the direction of economic development. The characteristics of

[7] Energy consumption elasticity coefficient refers to the proportional relationship between the energy consumption growth rate and the economy growth rate, which reflects the proportional relationship between energy consumption and economic growth. If the energy elasticity coefficient reach to one or even higher, requiring energy growth rate synchronize with economy growth and even expecting a faster energy growth. It shows the economy development is achieved by the low-level expansion of energy waste.

[8] National Bureau of Statistics of China. (2012). *Statistical Yearbook 2012*. Retrieved from http://www.stats.gov.cn/tjsj/ndsj/2012/indexch.htm

industrial location distribution and industrial structure of Chinese energy consumption is consistent, both showed "Secondary, Tertiary, Primary" mode. The period from now until 2020 is going to be the fastest growing period for Chinese industries. The proportion of heavy chemical industries within the industrial structure will still be high in this period, and the energy consumption structure of the three industries is hard to change fundamentally. So in order to reduce energy consumption, there should be a shift in the secondary industry away from traditional and towards high-tech industries together with an adjustment of the industrial structure to promote a new type of energy-intensive production. At the same time, the role of the tertiary industry should not be ignored. This should improve its structural proportion and energy use efficiency, thus promoting the gradual reduction of gross energy consumption in China.

2.3 Changes in Residents' Consumption Structure

Residents' energy consumption takes two forms: the first is through direct energy consumption, including household appliances, private transport, housing heating, etc.; the second is through indirect energy consumption, which refers to the high-energy consumption industries such as steel, cement, etc. that satisfies the daily needs of residents. Research shows that the residents' indirect energy consumption accounts for 40%-50% of annual energy consumption per capita (Bin & Dowlatabadi, 2005), and this consumption is trending upwards (Wei, Liu, & Fan, Y., et al., 2007). Compared with indirect energy consumption, residents' direct energy consumption represents a smaller proportion of the gross energy consumption. However, the changes in residents' direct energy consumption structure directly reflect the changes in residents' consumption preferences, and this is an important influencing factor for indirect energy consumption (Zhao & Li, 2011). In addition, as the economy develops and people's disposable income increases, the proportion of residents' direct energy consumption will continue to expand. For example, in 2009 American residents' direct energy consumption accounted for 22% of gross energy consumption, and took up 21% of USA gross carbon emissions (Min, Zeke, Qi, & High, 2010).

Chinese residents' direct energy consumption showed an obvious upward trend from the mid-1990s, and residents' direct energy consumption trend and gross energy consumption trend were consistent with each other. Chinese residents' direct energy consumption is a key influence on overall energy consumption (Zhao & Li, 2011). The improvement of residents' living standards and the enhancement of their purchasing ability are the most important causes of the rapid growth in Chinese residents' energy consumption. There has been a proportional increase in residents' expenditure on energy consumption; that is, a rise in the consumption of energy-intensive products such as household cars, motorcycles, air conditioning, heating, etc. Furthermore, the rise in widespread use of gas and natural gas in households has also led to the rapid growth of overall energy consumption. As China's economy grows rapidly and continuously, residents' increasing use of energy-intensive products will continue to present a growing trend. So improving the energy efficiency of these products will become a key factor in controlling China's gross energy consumption.

2.4 Urbanization

Urbanization is another major factor in the rapid growth of China's gross energy consumption. In the past decade, Chinese urbanization has significantly accelerated, and the urbanization rate rises by about 1% per year (The Chinese Academy of Sciences Strategy, para.4, 2012). The Chinese government issued the "Outline of the 'Twelfth Five-Year' Plan" (2011 to 2015) showing that China plans to raise the urbanization rate from its current level of 47.5% to 51.5% in 2015 (National People's Congress of China, 2011). Developments in recent years have shown that each percentage increase in China's urbanization raises energy consumption by 0.08 billion tons of coal equivalent (Wang, 2013). By 2015 the urbanization rate will be raised by 4%, which will trigger 0.32 billion tons of coal equivalent in energy consumption. 0.32 billion tons of coal equivalent brings this number very close to the limit demanded for gross energy consumption in 2015 – which stands at 0.38 billion tons of coal equivalent.

Chinese urbanization's impact on energy consumption is mainly reflected in the energy boost needed for infrastructure development, as well as the incremental rise of residents' energy consumption. With the acceleration of urbanization, there has been large-scale industrial infrastructure and residential construction which need a lot of energy-intensive products such as steel, cement, electricity and chemical products. The average annual energy consumption of China's urban population is approximately 3.5 times greater than that of the rural population. According to the current proportion of urban and rural population, even the urban population is increasing at a rate of about 1%, which means an increase of at least 13 million people, per annum. As rural residents are moved to cities or towns, the use of rural and non-commercial energy of fuel wood, straw, etc. will be replaced by commercial energy, mainly gaseous fuel, electricity, etc. and this will definitely result in a rise of gross energy consumption. In addition, the rapid development of urbanization requires continuous improvement of cities' supporting service systems, especially the urban transportation system and modern communications, which will also drive the rapid growth of energy consumption. Thus, in the process of urbanization, the control of gross energy consumption should be considered.

3. APPROACHES TO THE CONTROL OF CHINA'S GROSS ENERGY CONSUMPTION

To achieve the control targets for China's gross energy consumption, we must start with energy waste in various fields, and establish a long-term mechanism of energy conservation using both incentives and constraints.

3.1 Establishing the Allocation and Implementation Mechanism of Control Targets for Gross Energy Consumption

The central government should allocate gross control targets to every district, and local government should take full responsibility for the control of gross energy consumption in their administrative region. Gross energy control requires all provinces to control and even to reduce the energy consumption, which is equivalent to setting constraints on local economic growth. Local government may try to negotiate different target allocations because of their concern about economic development in their region. Therefore, allocation of local targets should be reasonable, and in line with local conditions.

It is recommended that the state set a target range for energy consumption control at an early stage in the implementation of the policy. This target range can act as a direction of focus or an oriented target, not as a binding target directly imposed on the regions. Each region should set its own time frame for implementation, and its own targets for gross energy control in line with the nationally set oriented targets. Later when the relevant conditions and the timing are mature, the government may consider changing the oriented targets into binding targets, and imposing them in various regions. The allocation and implementation of control targets for gross energy consumption should take on board the level of regional economic development, and responsibilities for energy conservation targets, etc. About 85% of the energy consumption quota should be in differentiated allocation to regions, whereas access to the final 15% of the quota could be won through a competitive auction, and the income from the auction could be used as regional transfer payments (Zhou, 2016).

3.2 Full Play of the Market Mechanism and Implementation of the Carbon Emission Trading Policy

Carbon trading is a market-based policy tool that governments use for coping with climate change. It is also an important measure in controlling gross energy consumption. Reasonable control of gross energy consumption, defining the gross energy control targets, and an allocation and implementation mechanism are equivalent to limiting gross carbon emissions. In November 2011, China's carbon emission trading pilot project started. Seven provinces and cities—Beijing, Guangdong, Shanghai, Tianjin, Chongqing, Hubei and Shenzhen—were identified as the first seven carbon emission trading pilot provinces and cities. A fully launch of the carbon emission trading of gross limits in these regions happens in 2013, and will expand nationwide in 2015. On June 18, 2013, the carbon emission rights trading in Shenzhen started, making it the first official pilot city to launch carbon emission trading. A total of 635 industrial enterprises and 200 large public buildings in Shenzhen have been included in the carbon emission trading pilot, becoming the first controlled enterprises. This means that these enterprises will undertake mandatory control of carbon dioxide emissions or face penalties. The enterprises that exceed the emission quota must purchase the difference in the carbon trading market, and the enterprises that have a surplus quota can choose to sell their quota in the market.

The Chinese government should develop relevant policies to encourage enterprises to participate actively in carbon trading, such as establishing an independent settlement account for enterprises which voluntarily conduct emission reduction trading. They should implement an accumulative system of trade credits, and treat an enterprise's carbon trading record as an important document for it to use in applying for or obtaining certain qualifications or rights. On the one hand, it could be decided that fiscal and financial priorities could obtain once an enterprise's carbon trading record reached a certain level of accumulation. On the other hand, enterprises could obtain a level of priority for their future emission credit according to their accumulative trading volume. Meanwhile, the government should accelerate the establishment of a domestic carbon trading platform to ensure the smooth progress of carbon trading; enhance the monitoring, verification and certification of carbon emission, to enable long-term sustainable trading; speed up the construction of a carbon trading registration system, structure and perfect its content to include at least project information, authentication information and trade information. This can start as a regional registration system and gradually become established as a unified national registration system; last of all, the government should strengthen their propaganda to raise public awareness about carbon trading.

3.3 Strengthen Basic Work on Energy Accounting Analysis

An accurate and reliable energy accounting system is the basis for promoting and assessing the realization of control targets for gross energy consumption. For example, the energy statistics from the U.S. Energy Information Administration (EIA) cover coal, oil, natural gas, electricity and other major energy varieties, as well as other important information on energy policy, electricity market reform, etc. The statistical cycle can be subdivided to days, weeks, months, quarters, or years according to the

data type, and the EIA regularly issues all kinds of analysis and forecast reports, which play an important guiding role on investment and consumption activities. China's current organization of national energy statistics and analysis is still weak. The government should establish and perfect an analysis system of classified energy statistics which would include a survey system of classified terminal energy use in the industry, construction, transportation, public agencies, residents' lives and so on. It should also improve the statistical calculating system that covers every aspects of classified energy consumption; and it should unify the national and regional energy statistical index.

The Statistics Department should further strengthen the implementation of the energy utilization reporting system of key energy-use enterprises. It should force all key energy-use enterprises, whose energy consumption takes up more than 60% of the country's gross energy consumption, to adopt the enterprise energy statistical analysis software; and it should organize large-scale training for statisticians to make them proficient in using the enterprise energy statistical analysis tools. With reference to the experience of Japan, the national energy departmental head should consult with the human resources department to establish and implement an enterprise energy manager system. The government should organize special inspection of the allocation of energy measurement equipment among the key energy-use enterprises, and offer those unqualified enterprises a deadline for rectification. Fort those that remain unqualified after the deadline, the government should cancel their qualification for the preferential policies on national energy conservation finance, taxation, etc. and carry out accountability system.

3.4 Promote Industrial Transformation and Develop New Low-Carbon Industries

China should increase the structural proportion of the tertiary industry, properly lower the structural proportion of the secondary industry, and help the primary industry to enhance its efficiency on the basis of its present structural proportion. In this way, China can achieve economic growth and seek to maximum energy conservation and consumption reduction.

The realization of China's gross energy consumption control needs to rely on the increase of industrial energy-use efficiency. Within the structure of the sector, the proportion of industrial energy-use is declining, but it is still the largest energy consumption sector, of which the energy consumption involved in transportation and construction are the fastest growing parts. To gain an increase in energy-use efficiency, it is necessary to promote clean production. This can be achieved by promoting the conversion of high energy consuming and high polluting industries into industries that work to conserve resources and protect the environment. To this end, they must eliminate backward technology and improve production capacity, as well as promoting energy conservation and emission reduction by technological innovation. They need to reduce costs through the scale of production and by making use of an industrial clustering effect, and they need to develop an eco-industrial zone.

By developing new low-carbon industries, eliminating backward production capacities which lack scale effects, such as iron-making, steelmaking and cement-making; by developing the recycling and renewable resource industries, reducing consumption of resources and energy; by actively developing clean and renewable energy, replacing traditional high-carbon fossil fuels, and by gradually establishing a low-carbon energy system, a low-carbon technology system and a low-carbon industrial structure, the government can gradually transform economic development from a traditional mode of production to a low carbon economy. This is clearly China's long-term direction of industrial transformation and the inevitable choice implicit in gross energy consumption control.

3.5 Strengthen a Low-Carbon Society Construction and Promote Low-Carbon Urbanization

In the development of urbanization, the first thing is to promote urban low-carbon. In the process of urban and rural planning, industrial structure layout, land use and construction, priorities should be given to ecological carrying capacity and an energy support force, so forming a benign circle in the development of protection and in the protection of the development. This is inseparable from the government's financial support, so they should gradually increase investment by the proportion of output value, and transform urban development from a requirement to "expand space" to one that will "raise function", building a new mode of "Four in One" urban development of low carbon transportation, low carbon building, low carbon community and low carbon Family.

Strengthening the construction of low carbon society and promoting low carbon urbanization should include new energy development in urban construction planning. In order to provide clean and efficient energy support for urbanization, as well as to keep gross energy consumption under control, China should fundamentally adjust the coal-dominated energy consumption structure. It should raise the proportion of new energy and renewable energy and other clean energy in energy consumption. In essence, the new energy and renewable energies are characterized by low or zero-emissions, so fundamentally solving the limitations and exogenous pollution problems of fossil fuels. The government can be supportive in various ways such as franchise, government procurement, pilot demonstration and subsidies for generating electricity with new energy. For example, at the beginning of urban construction and renovation, they can promote ecological civilization construction simultaneously in various fields

such as green residence (solar thermal, photovoltaic), green transportation, green consumption, etc.

CONCLUSION

The Chinese government has proposed a target of controlling national gross energy consumption at 4 billion tons of coal equivalent in 2015, marking the transformation of China's energy strategy from one that mainly secures the supply to one of gross energy consumption control. This is a revolution as well as a challenge to the traditional mode of thinking. Internationally, the implementation of gross energy consumption control has no precedent, whether in the developed or in the developing countries. China will be the first country to achieve this.

As an administrative act, gross energy consumption control is controversial. But facing the exhaustion of natural resources and a deteriorating ecological environment, and with the national conditions that come with a large population, deficient resources and at the stage as a developing country, China has taken the initiative towards self-restraint by lowering its economic growth target in the "Twelfth Five-Year" period (2011-2015) and voluntarily controlling its gross energy consumption in the future. China is setting an example for other economies by fulfilling the common but differentiated responsibilities internationally on the control of carbon dioxide emission, but also by making a contribution to the whole world energy security.

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