

# Comparison of Energy Efficiency of Developed Regions in China at Similar Economic Level between 1995 and 2007

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## Abstract

Economic level could be an important factor which influences energy efficiency and it's generally accepted that high level of economic development can lead of high energy efficiency. However, the situation may be different when economic factor is put aside. In the paper, nine regions in China are chosen to compare their energy efficiency at similar economic level between 1995 and 2007. Based on the result, the nine regions can be divided into three categories--early developed regions with low energy efficiency, late developed regions with high energy efficiency and late developed regions with low energy efficiency. Three possible reasons for the result (the technology "leapfrog", energy mix and industrial mix) are discussed. The adoption of the latest technologies, low portion of coal-driven energy in energy mix and high portion of light industry in industrial mix can be the reason for high energy efficiency of late developed regions in China.

**Keywords:** Energy Efficiency, Similar economic level, Developed regions in China

## 1. Introduction

Since the reform and opening up policy adopted in 1978, China has achieved extraordinary economic growth. China's GDP witnesses a tremendous increase, rising from Rmb362.4 billion in 1978, to Rmb30 trillion in 2008 (Chinability, 2009). Between 1979 and 2008, China's average annual GDP growth rate was approximately 10% (Liu, 2009). It is estimated that China will overtake the USA and the EU as the biggest economy of the world by about 2018, and by 2030 it will have a GDP of about double the USA GDP. Per capita income will rise about 11 times, approaching about 60 % of USA income, and surpassing a number of other countries in the world (Simonsen, 2009).

For most economic activity, energy is a required input and thus an engine for economic growth (Lee, & Chang, 2007). Energy consumption has been linked to a large spectrum of development concerns including sustainable development, industrial development, air and atmosphere pollution and climate change (United Nations, 2006). That's the reason that energy use and related issues are high on international and academic agendas (Tickell, 2008; Dhakal, 2008; United Nations Development Programme, 2007). Scholars (Marcotullio, & Schulz, 2008) have examined energy transition at developed and developing countries during similar economic level. Results show that energy transitions happens sooner, faster, more simultaneously, more efficiently and with lower systemic global environmental impact in rapidly developing Asia-Pacific countries than in USA. Among the five characteristics of energy transitions, more efficient energy transition means that energy efficiency is higher in rapidly developing Asia-Pacific countries than in USA during similar economic level. However, it points out the limitation that trends identified at the national level cannot be assumed to occur at other scales. Therefore, it is interesting to study whether the trends identified at the national level can be assumed to occur at smaller scales, for instance, whether energy efficiency is higher in late developed regions than in early developed regions in China during similar economic level. Energy efficiency (energy input/economic output) by region in China during a certain period has been studied by some scholars. Hu and Wang have analyzes energy efficiencies of 29 administrative regions in China for the period 1995–2002 with a newly introduced index (Hu, & Wang, 2006). Han et al. (2007) report the empirical study of the impact of China's energy structure on its energy efficiency from 1978 to 2003. Wu, et al. (2006) study energy supply-side and demand-side effects on energy-related CO2 emissions in China during 1980 to 2002. However, all the studies compare energy efficiency by region during the same period, in other word, under different economic level. Economic level may be a factor which could influence energy efficiency. For example, regions with stronger economic growth may afford the state of art equipment or master the latest technology to improve its energy efficiency; regions with stronger economic growth may also be able to shift its dominating sector from secondary to tertiary industry, which can greatly improve energy efficiency. When comparing energy efficiency by region during the same period, early developed regions, such as Beijing and Shanghai, often rank top of the list and are praised for their high energy efficiency (Net Ease, 2009). However, what may the result be if the impact of economic level is put aside, in other word, energy efficiency of different regions are only compared under the same economic level? Could early developed regions still rank top? If the ranking is different, what regions will rank top? Why some regions can have higher energy efficiency than others even when they have made similar economic achievement? What could be learnt from those energy-efficient regions?

The main purpose of the study is to discover what regions enjoy high energy efficiency when the influence of economic factor is put aside and why these regions can have higher energy efficiency than others even when

they have made similar economic achievement. The rest of the paper is organized as follows. Section 2 provides data and analysis and section 3 discusses the result. The final section provides some concluding remarks.

## 2. Data and Analysis

Data of Gross Regional Product (GRP) and population of each region between 1995 and 2007 are obtained from China Statistical Yearbooks from 1995 to 2007 (National Bureau of Statistics of China, 1995-2007a). According to the level of economic development (GRP/capita), nine developed regions in China are chosen for the study. Among the nine regions, three (Beijing, Shanghai and Tianjin) are early developed regions while other six (Zhejiang, Guangdong, Fujian, Liaoning, Hebei and Inner Mongolia) are late developed regions. To put aside economic factor, only periods when the nine regions at similar economic level (GRP/capita) are chosen to compare their energy efficiency (see Table 1).

In the paper, Total Final Consumption per unit Gross Regional Product (TFC/GRP) is adopted to evaluate energy efficiency. TFC is calculated through data of energy balance by region obtained from China Energy Statistical Yearbooks from 1995 to 2007 (National Bureau of Statistics of China, 1995-2007b).

The result is shown in Table 2. According to the result, the nine regions can be divided into three categories: Beijing, Shanghai and Tianjin belong to early developed regions with low energy efficiency; Zhejiang, Guangdong and Fujian are late developed regions with high energy efficiency; Liaoning, Hebei and Inner Mongolia are late developed regions with low energy efficiency.

## 3. Discussion

There are three reasons for the difference in TFC/GRP of the nine regions at similar economic level.

### 3.1 "Leapfrog" of technologies and equipments

"Leapfrog" of technologies and equipments has been used by scholars to explain the trends of increasing energy efficiency experienced by developing 'late-comers' (Goldemberg, 1998; Ho, 2005; Smith, 1993; Marcotullio, & Schulz, 2008). In the paper, "leapfrog" of technologies and equipments can also be used to explained different energy efficiency between early developed regions and late developed regions. Technologies and equipments develop with times. Technologies and equipments which were new and innovative and energy-saving in the past to early developed regions when they developed their economy seem to be old and outdated and energy-consuming nowadays to late developed regions when they developed their economy. When late developed regions developed their economy, they were not stuck with the outdated technologies and equipments but adopted the latest inventive technologies and equipments which were more energy-saving than the old ones. By using modern technologies and equipments, late developed regions can bypass problems experienced by the early developed regions (i.e. 'leapfrog' over challenges). Late developed regions have the opportunity to 'do it right the first time' by installing clean efficient technologies, among other changes.

It is possible that the more open the economy of a region is, the more possible the region adopts the latest technologies and equipments. The inflow of foreign direct investment in the forms such as foreign own companies or joint-venture companies may possibly bring the latest technologies and equipments to regions in China which receive the investment. Beijing, Shanghai and Tianjin are open in their economy, however, they are early developed regions and the technologies and equipments they adopted at that time were less energy-efficiency than those adopted by late developed regions. Zhejiang, Guangdong and Fujian are coastal regions and are the main areas which receive foreign direct investment in China. Liaoning and Hebei are also coastal regions, however, locating at the north part of China, they cannot enjoy the advantages that Zhejiang, Guangdong and Fujian do, all of which are coastal regions and locate in the middle and south China. Inner Mongolia is the only inner region studied in this study. It's a late developed region with its TFC/GRP the largest among all the eleven regions. It's possible that due to its relatively closed location, Inner Mongolia cannot enjoy the latest technologies and equipments as other coastal regions do. In addition, some suggest that the establishment of appropriate conditions for leapfrogging requires a host of abilities including institutional capacity. (Ho, 2005; Marcotullio, & Schulz, 2008) Governments in regions with more open economy may probably be more willing to support the adoption of the latest technologies and equipments.

### 3.2 Energy mix

Since different energy source has different energy value, the difference of energy mix in utilization may lead to different TFC/GRP. To see the difference of energy mix of the nine regions at similar economic level, different energy sources for the nine regions are examined. The results are shown in Table 3. IP/TFC (Electricity) is the proportion of Indigenous Production of electricity in terms of Total Final Consumption. Indigenous Production of electricity denotes electricity is produced within the region by energy resources other than thermal power plants, i.e. hydro power, nuclear power, wind power, etc.

Table 2 and 3 show that for the three coastal regions which have small TFC/GRP (Zhejiang, Guangdong and Fujian), their energy mix is very diverse and the distribution of different energy source is more even than other regions. Another obvious difference is the proportion of electricity. For the three early developed regions (Beijing, Shanghai and Tianjin), the proportion of *Electricity* is no larger than 20%. However, for the three late

developed regions which have small TFC/GRP, the proportion of *Electricity* is larger than 20%. For other three late developed regions which have large TFC/GRP (Liaoning, Hebei and Inner Mongolia), the proportion of *Electricity* varies. Among the nine regions, regions with large proportion of *Petroleum Products Total* and *Electricity* have small TFC/GRP.

Electricity is an important energy. However, whether it is clean or not depends on the way it is produced. Burning fossil fuels, especially coal, is one of the ways to generate electricity and it's still the dominant way in China, where coal reserve is relatively large and coal is relatively cheap. If the electricity is actually from some other coal-fired power plants, then it's just the same as coal as a source of power, but worse, because there is loss of power getting the power to the city from some remote site. But there may be a pollution difference locally, but not in total because of the transportation of electricity among different regions. The proportion of IP/TFC (Electricity) indicates how much of the electricity generated within the region is generated by energy sources other than burning fossil fuels, including hydro power, nuclear power, wind power, solar power, etc. Table 3 shows that for the three late developed regions (Zhejiang, Guangdong and Fujian) which have small TFC/GRP, their IP/TFC (Electricity) is much larger than the three early developed regions (Beijing, Shanghai and Tianjin), which have large TFC/GRP, and other three late developed regions (Liaoning, Hebei and Inner Mongolia) which have large TFC/GRP. The reason why regions with high IP/TFC (Electricity) have small TFC/GRP is very interesting but not so clear. It may be that because these regions are fast developed in their economy and also require a huge amount of energy, therefore, the central government notices the trend and set out the strategy to diversify the energy mix and also decrease the proportion of energy generated from coal. Hydro power plants, nuclear power plants are being built in these regions, which provide a large amount of energy generated from resources other than coal for the development of the regions.

### 3.3 Difference of Industrial Mix

Difference of industrial mix within a region may be another reason for the difference in TFC/GRP. In China, the second industry is the dominant energy-consuming sector compared with the primary and tertiary industry (Zhang, 2003) while within the second industry, heavy industry is much more energy-consuming than the light industry. The reason why Zhejiang, Guangdong and Fujian have smaller TFC/GRP than Liaoning, Hebei and Inner Mongolia may be the proportion between heavy and light industry. Liaoning has been a traditional heavy industrial base even since the founding of the People's Republic of China. Inner Mongolia is endowed with a large amount of natural resources which paves way for its development towards a heavy industrial base. Hebei, borders on both Inner Mongolia and Liaoning, has an economic structure which tilts to heavy industry. In comparison, due to the advantage of their geographical location, the economy of Zhejiang, Guangdong and Fujian is more export-oriented, of which light industry plays a very significant role.

## 4. Conclusion

Economic level is an important factor which influences energy efficiency. When early developed regions are compared with late developed regions during the same period, the general concept is that early developed regions will certainly have higher energy efficiency than late developed regions. Thus early developed regions are always being praised for their high energy efficiency. However, the result can be different when the impact of economic level is put aside. In the paper, nine regions in China are chosen to compare their energy efficiency at similar economic level between 1995 and 2007. The author discovered that early developed regions which usually have high energy efficiency no longer keep the trend. The nine regions studied can be divided into three categories—early developed regions (Beijing, Shanghai and Tianjin) with low energy efficiency, late developed regions (Zhejiang, Guangdong and Fujian) with high energy efficiency and late developed regions (Liaoning, Hebei and Inner Mongolia) with low energy efficiency. The reasons why the three late developed regions have high energy efficiency include “leapfrog” of technology and equipments, the difference of energy mix (more diversified and lower proportion of coal-driven energy) as well as industrial mix (the more even proportion of heavy and light industry). Late developed regions, Zhejiang, Guangdong and Fujian, may be better models for less developed regions when they embark their development because the situations of these late developed regions are more similar to less developed regions than early developed regions due to short time interval between the development of late developed regions and less developed regions.

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Table 1. Period of Comparison and GRP/capita Range for nine regions

	Period of Comparison	GRP/capita Range (yuan)
Beijing	1997-1999	16735-19846
Tianjin	2000-2001	17993-20154
Shanghai	1995-1996	17403-22275
Zhejiang	2002-2003	16838-20147
Guangdong	2003-2004	17213-19707
Fujian	2004-2005	17218-18646
Liaoning	2004-2005	16297-18983
Hebei	2006-2007	16962-19877
Inner Mongolia	2005-2006	16331-20053

Source: Summarized by the author from China's Statistical Yearbooks (National Bureau of Statistics of China, 1995-2007a).

Table 2. TFC/GRP of nine regions (ton of Standard Coal Equivalent /10,000yuan)

	Beijing	Shanghai	Tianjin	Zhejiang	Guangdong	Fujian	Liaoning	Hebei	Inner Mongolia
1995		0.97							
1996		0.77							
1997	1.08								
1998	1.16								
1999	1.02								
2000			1.16						
2001			1.07						
2002				0.62					
2003				0.56	0.64				
2004					0.55	0.48	0.94		
2005						0.62	0.94		1.34
2006								0.81	1.16
2007								0.77	

Source: Calculated by the author from China's Statistical Yearbooks (National Bureau of Statistics of China, 1995-2007a).

Table 3. Energy mix of TFC and the IP/TFC for eleven regions

	Coal Total	Petroleum Products Total	Natural Gas	Electricity	Other Energy	Heat	IP/TFC (Electricity)
Beijing (1997-1999)	38%	30%	1%	14.5%	6%	10.5%	3%
Shanghai (1995-1996)	30%	42%	0%	19.5%	2.5%	6%	0%
Tianjin (2000-2001)	37%	35%	3.5%	13%	0%	11.5%	0%
Zhejiang (2002-2003)	32.5%	32%	0%	25.5%	0%	9%	21.5%
Guangdong (2003-2004)	22%	48%	0%	27.5%	0.5%	2%	22.5%
Fujian (2004-2005)	38.5%	36.5%	0%	23.5%	0.5%	1%	33.5%
Liaoning (2004-2005)	34%	30.5%	3%	18%	1%	13.5%	4.5%
Hebei (2006-2007)	56%	15.5%	1%	21.5%	1.5%	4.5%	0%
Inner Mongolia (2005-2006)	54%	19%	2.5%	17.5%	1%	6.5%	2%

Source: Calculated by the author from China's Statistical Yearbooks (National Bureau of Statistics of China, 1995-2007a).