"Working Together to Respond to Climate Change"

Annex I Expert Group Seminar in Conjunction with the OECD

Global Forum on Sustainable Development

Energy Efficiency Policy and CO_2 in China's Industry: Tapping the potential

(First draft, unedited)

Wang Yanjia

Tsinghua University, Beijing, China

Background information for presentation to be given by Wang Yanjia at the Annex I Expert Group Seminar in Conjunction with the OECD Global Forum on Sustainable Development on 27 March 2006

20 March 2006

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**
1. INTRODUCTION **2**
1.1 BACKGROUND 2
1.2 STUDY SCOPE AND OBJECTIVES 3
1.3 OUTLINE OF THE REPORT 3
2. POSITION OF INDUSTRY IN CHINA **3**
2.1 SCOPE OF INDUSTRY 3
2.2 INDUSTRIAL FABRIC ANALYSIS 8
3. ENERGY EFFICIENCY OF ENERGY-INTENSIVE INDUSTRIAL SECTORS **11**
3.1 TARGET-DRIVEN DEVELOPMENT 11
3.2 ENERGY EFFICIENCY OF INDUSTRY 13
3.3 EVOLUTION OF INDUSTRIAL ENERGY EFFICIENCY 14
4. REVIEW OF ENERGY EFFICIENCY POLICY FOR INDUSTRY **19**
4.1 TRACKING ENERGY EFFICIENCY POLICY 19
4.2 OVERALL GOALS FOR ENERGY EFFICIENCY IMPROVEMENT 21
4.3 MEASURES FOR ENERGY EFFICIENCY IMPROVEMENT IN INDUSTRY 22
5. AN ANALYSIS OF ENERGY EFFICIENCY POLICIES IMPLEMENTED IN CHINA'S INDUSTRY **27**
5.1 ENERGY CONSERVATION LAW 27
5.2 CLEANER PRODUCTION PROMOTION LAW 29
5.3 CHINA MEDIUM AND LONG TERM ENERGY CONSERVATION PLAN 31
5.4 POLICY OUTLINES FOR ENERGY CONSERVATION TECHNOLOGIES 34
5.5 INTERIM REGULATIONS ON PROMOTING THE ADJUSTMENT OF INDUSTRIAL STRUCTURE 35
5.6 SUPERVISORY METHOD OF ELECTRICITY CONSUMPTION CONSERVATION 37
5.7 ENERGY EFFICIENCY STANDARDS 37
5.8 SUPERVISORY METHOD OF ENERGY CONSERVATION FOR KEY ENERGY CONSUMERS 37
5.9 ENERGY AUDITING 38
5. 10 FROM ENERGY CONSERVATION SERVICE CENTER TO EMCS 38
5.11 DEMAND SIDE MANAGEMENT 41
6. ALTERNATIVE POLICY TOOLS **44**
6.1 ENERGY-EFFICIENCY AGREEMENT (VOLUNTARY AGREEMENT): PILOT PROJECTS 44
6.2 ENERGY TAX 46
6.3 ENERGY MANAGEMENT INFORMATION SYSTEM 47
7. CONCLUSIONS **47**
8. REFERENCE **49**

Executive Summary

China's industry emitted 2290 Mt-CO_2 in 2003, accounting for 60.9% of the nation's total. Although energy efficiency in industry improved a lot in the recent two decades, it is still far behind the world's best practice. Improving energy efficiency through proper energy efficiency policy could reduce industry's CO_2 emissions tremendously.

China's industry plays a very important role in its economic development, with more than 40% of the country's annual GDP. Within industry, the share of gross output from state-owned and state-holding enterprises was 35.2% in 2004. The contribution from foreign funded enterprises and enterprises funded by Hong Kong, Macao and Taiwan has reached 31.4% and private enterprises 16.5%.

The industrial sector's final energy consumption amounted to 562.8 million toe (tons of oil equivalent) in 2003, that is 67.6% of total final energy. 20.6% of it is used in non-energy uses. 447.1 million toe of energy were consumed as fuels in industrial sectors.

In industry's total CO_2 emissions, near half (1 124 Mt-CO_2) came from fuel combustion; another 1 166 Mt-CO_2 were emitted as a result of industry's electricity consumption.

During the tenth five-year plan period (2001-2005), energy-intensive industrial sectors like steel and cement presented a high growth trend, accompanied by a rapidly growing energy use. The energy intensity of GDP remained almost constant over the past few years, whereas the 90s recorded a rapid decline.

The energy intensity of main industrial products in China is much higher than that of developed countries, when measured in energy use per unit of physical output. Comparisons between various Chinese plants indicate huge potentials for energy efficiency improvement.

Small-scaled equipment, outdated production process and low operational efficiency are common factors explaining the low energy efficiency in China's industrial sector. These problems have been known for years, and in spite of many efforts to address with them, remain true today.

The government has adopted mainly administrative methods to limit the utilization of outdated production processes and shut down inefficient small-scaled enterprises. The effectiveness of such government orders is mixed. Although some facts indicate the growing role of market forces, how to build a favorable market environment to promote energy efficiency remains an issue for further work.

Energy efficiency policy in China experienced the changes from a centrally-planned to a more market-oriented economy. Many policies have been implemented, providing a legal framework, technology development guidelines and policy tools to energy efficiency improvement activities in industry. 14 energy efficiency policies or measures including the Energy Conservation Law, the Cleaner Production Promotion Law, the Medium and Long-Term Energy Conservation Plan and other tools are reviewed, highlighting the main content of each policy and its effectiveness.

Many considerations are driving efforts towards energy efficiency improvement. CO_2 emission reductions, however, are only a by-product of energy efficiency policies, usually not mentioned as a motivation for these policies. Although China's Medium and Long Term Energy Conservation Plan indicated a quantitive energy efficiency improvement target by 2020, and even provided quantitative targets for energy conservation and SO_2 emission reductions, CO_2 emission reductions were not presented in the Plan. The only official document mentioning the greenhouse gas dimension is the recently published "Suggestions for the eleventh five-year national economic and social development plan" passed by the 5th Plenary Meeting, Sixteenth National Congress of the Communist Party of China held in October of 2005. If China were to meet its energy conservation target by 2020, it would avoid the emission of some 3.4 Gt-CO_2 from 2003 to 2020.

In general, most policies are based on clear principles but lack implementation details. Even policies that address very detailed issues, such as a listing of technologies supported or prohibited by the government, are taken as general guidelines or directions rather then measures. Meanwhile, most policies are qualitative rather than quantitive. It is therefore difficult to evaluate the effectiveness of the various policies. Although financial support to energy efficiency improvement is part of many policies, the budget allocation is often separated from the policy itself.

China intends to adopt policy tools that have proven effective in other countries. Much effort will be needed to ensure the effectiveness of new approaches.

1. Introduction

1.1 Background

China is the second-largest CO_2 emitter in the world, surpassed only by the United States. Energy efficiency improvement is one of important measures for reducing CO_2 emissions. Industry is the main energy consumer and CO_2 emitter in China. Improving energy efficiency through implementing energy efficiency policy in industry could benefit local environment, globe environment and industry itself. Energy efficiency improvement is also an important aspect for policy dialogue, business development

and international trade between China and OECD countries.

1.2 Study scope and objectives

The objective of the report is to provide an overview of energy efficiency policies in China's industry, from a CO_2 emission reduction perspective. It addresses energy consumption and CO2 emissions from industry (excludes electricity generation sector) and focuses on analysis of various energy efficiency policies and their implementation.

1.3 Outline of the report

Following this introduction, the report sketches the position of industry in China in terms of contribution of GDP, industrial fabric energy consumption and CO2 emissions. In a chapter of energy efficiency of energy-intensive industrial sectors, the report describes the progress on efficiency improvement and briefly compares the energy intensities of several products among the China's average level, China's advanced level and OECD countries. In the succeeding chapter on energy efficiency policy for industry, the report reviews the changes in overall goals for energy efficiency improvements in industry, and explains what specifically is driving China's efforts to improve efficiency.

The following two chapters introduce the contents of main energy efficiency policies and status of their implementation. Energy Conservation Law, Clean Production Promotion Law, China medium and long term energy conservation plan, policy outlines for energy conservation technologies, interim regulation on promoting the adjustment of industrial structure, energy-efficiency voluntary agreement and other measures totally 14 policy aspects are discussed.

The final chapter of this report summarizes the conclusions delivered from this study.

2. Position of industry in China

Industry plays a very important role in China's economy, energy consumption and CO_2 emissions. This section clarifies the scope of industry in terms of economic contribution, energy consumption and CO_2 emissions. An analysis on industrial fabric will be presented for giving a picture on Chinese industry.

2.1 Scope of industry

Based on China's national standard of sectoral classification, industry scope in terms of contribution of GDP includes three main parts:

1. Mining and Quarrying (referred to here as mining)
2. Manufacturing
3. Electric Power, Gas and Water Production and Supply (referred to here as power)

Together with contribution from construction, the total value-add from secondary industry accounted for 46.2% of GDP in 2004 according to the national economic census results (BYD 2005). This figure is 6.7 percentage points lower than the one published by National Bureau of Statistics in 2005 China Statistical Yearbook. Chinese government also published the corrected data of GDP and value-added for primary, secondary and tertiary industry from 1993 to 2004. Since the very limited results from the census have been published and there is no corrected historical value-added data for industrial sectors, the following analysis is based on the data from 2005 China Statistical Yearbook.

In 2004 the share of industry in GDP was 45.9%. This share changed between the lowest 37% in 1990 and the highest 45.9% in 2004. The GDP and value-added of industry from 1990 to 2004 is shown in Figure 2.1. The contribution from industry includes the contributions from mining sectors which are normally belong to primary industry in other countries and the contributions from electric power industry which is out of research scope of this report.

In 2003, China totally consumed primary energy 1.2 billion toe[1]. Industry consumed 70% of it. The data is given by the overall energy balance sheet from China Energy Statistical Yearbook 2004 that has allocated electricity consumption to each sector on the bases of coal equivalent calculation as shown in Figure 2.2.

The final energy consumption was 1.14 billion toe in 2003 and in which industrial sector consumed 0.83 billion toe accounted for 72% of the total. These data are calculated based on coal equivalent calculation method. Another final energy consumption of industry that converting electricity into toe on the base of calorific value[2] is also given by the yearbook. The final consumption of industry (calorific value calculation) was 563 million toe. In which, manufacturing sector consumed 480 million toe, 85% of industrial total as shown in Figure 2.3.

[1] Converting electricity produced by hydropower and nuclear power no the bases of average coal consumption per kWh at coal-fired power plants in the same year that's called coal equivalent calculation.
[2] 1 kWh = 860 kcal

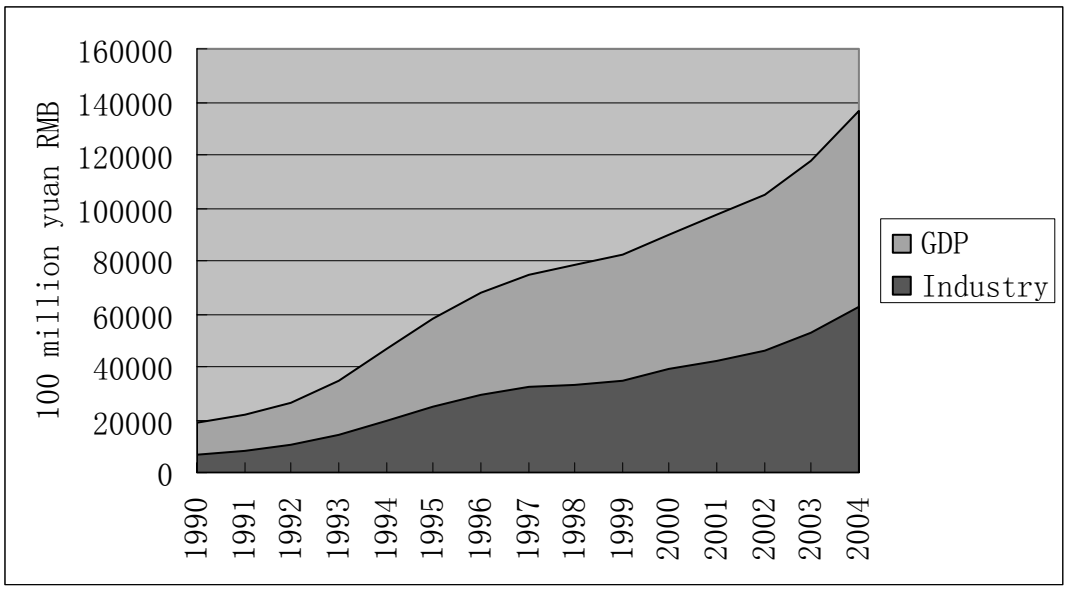

Figure 2.1 China's GDP and value-added of industry (1990-2004)
Source: NBS (2005a) Page 51

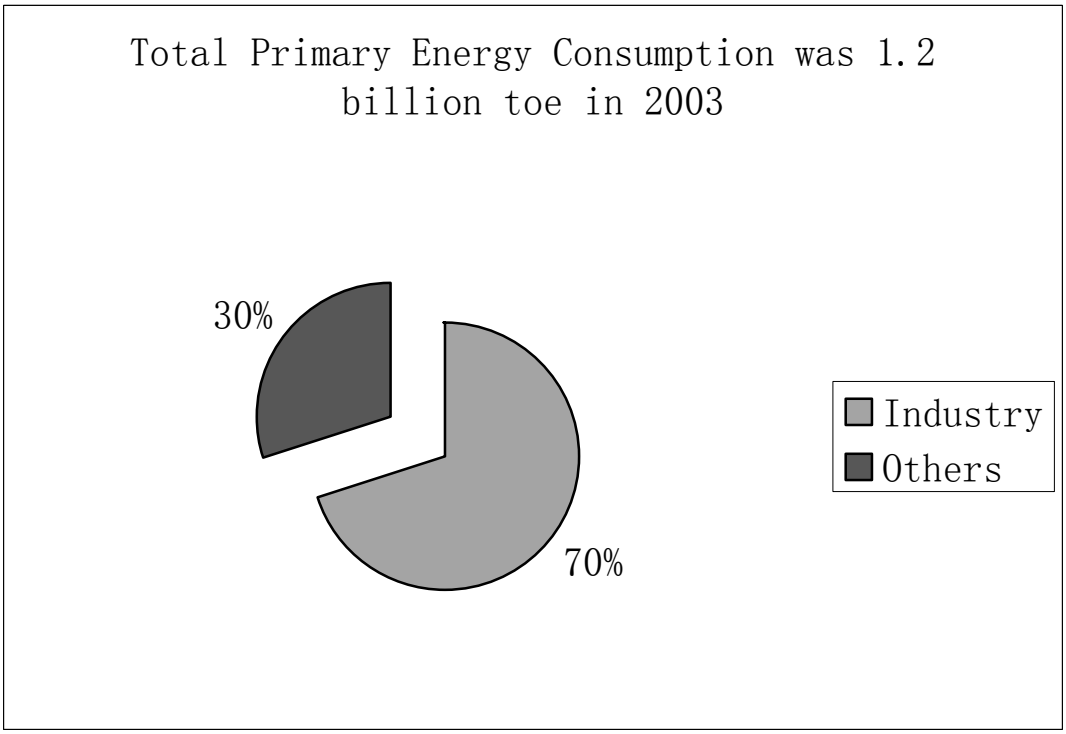

Figure 2.2 Total energy consumption and the share of industry
Source: NBS (2005b) Page 75.
Coal equivalent calculation

Since this report focuses its analysis on energy-intensive industries such as iron & steel and cement, it uses 'others' to present the rest sectors in manufacturing. The standardized sector's name and classification can refer to Annex I.

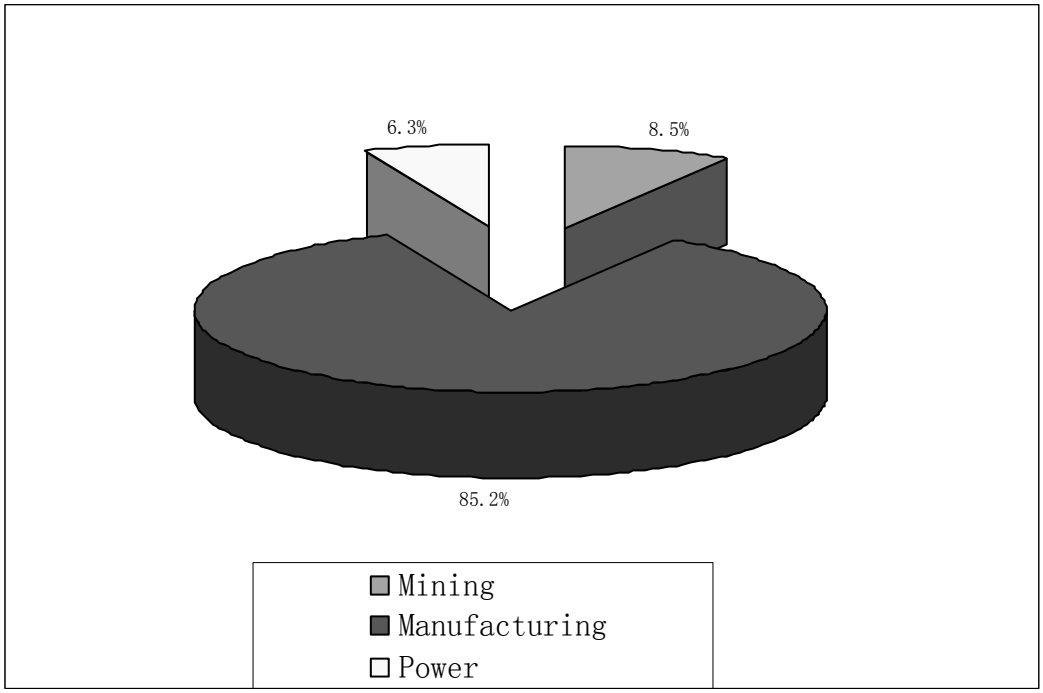

Figure 2.3 Final energy consumption mix of industry in 2003
Source: NBS (2005b) Page 119

Table 2.1 shows the final energy consumption of industry by different sort of energy form. In 2003, industry consumed 562.8 million toe and in which 115.7 million toe for non-energy use. Figure 2.4 shows the position of industrial final energy consumption in total energy consumption. It indicates through energy conversion and distribution, 39% of primary energy is consumed by industrial for final energy use.

Table 2.1 Final Energy Consumption of Industry in China (2003) (million toe)

Energy sort	Total consumption (Non-energy use)	Note
Coal total	175.6 (52.7)	Including raw coal, cleaned coal and other washed coal
Coke	95.0 (5.9)	
Coal gas	21.2 (0.6)	Including coke oven gas, other gas and other coking products
Petroleum products total	105.4 (48.1)	Including crude oil, gasoline, kerosene, diesel, fuel oil, LPG, refinery gas and other petroleum products
Natural gas	22.3 (6.2)	
Heat	32.4 (0)	
Electricity	108.7 (0)	1263.9 TWh
Others	2.2 (2.2)	
Total	562.8 (115.7)	

Source: NSB (2005b) Page 66-73

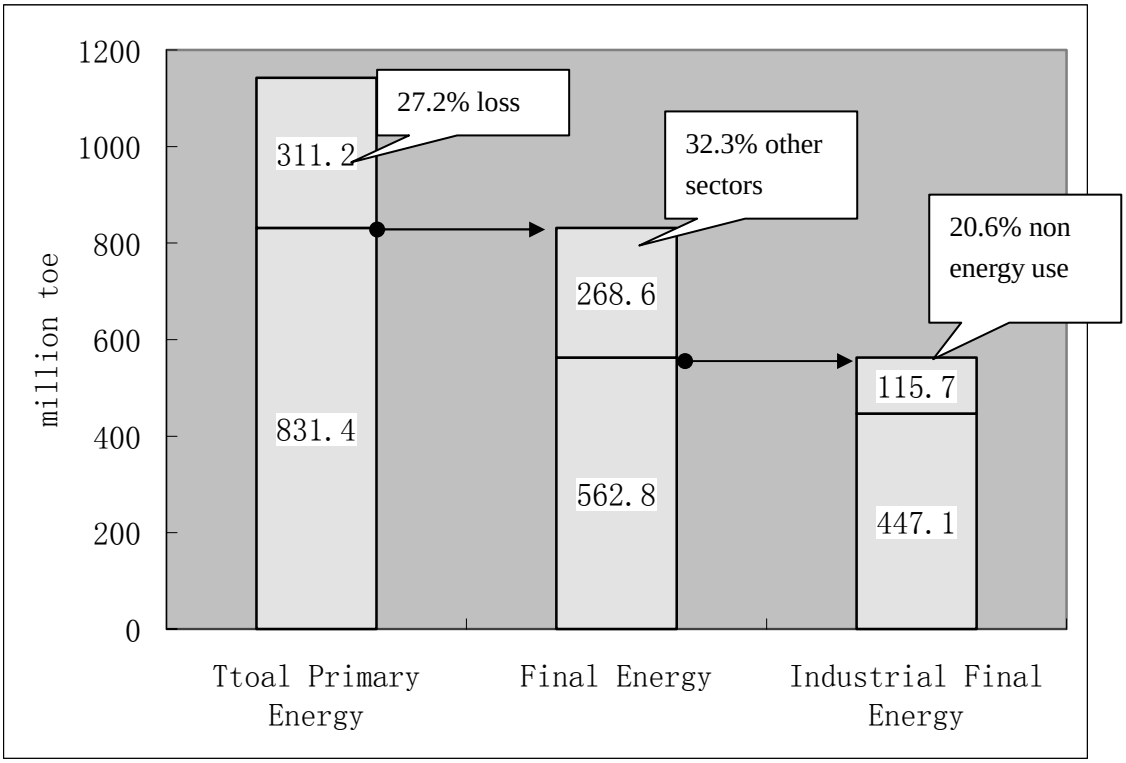

Figure 2.4 Industrial energy consumption in TPE (2003)

Source: NSB (2005b) Page 66-73

The CO2 emissions from fuel consumption of industry can be estimated based on the data in Table 1 and divided into two parts: one is direct emission from burning fossil energy; the other is indirect emission from consuming electricity and heat. Table 2.2 shows the estimation of CO2 emissions from industrial energy use in 2003. It indicated that the direct emission was 1124 million tonne of CO2 and indirect emission 1166 million tonne of CO2. The total CO2 emissions of industry were 2289.5 million tonne of CO2. Up to now, China only published one set of GHG emission data of 1994 officially. All other emission data, especially CO2 emissions are calculated based on energy consumption and haven't got formal authorization. According to IEA's estimation, China emitted 3760 million tones of CO2 from fuel combustion in 2003 (IEA 2005). The direct emission of industry accounted for 30.0% of total, and the indirect emission of industry accounted for 30.9% of total. Combing these two parts, 60.9% of the emissions came from industry in China in 2003.

Table 2.2 CO2 emissions of industry from fuel combustion in China (2003)

Energy sort	Final consumption[3] (Mtoe)	Emission factor[4]	CO2 emissions (M t-CO2)
Coal-based	232.6	3.92 t-CO2/toe	911.8
Oil-based	57.3	3.05 t-CO2/toe	174.8
NG-based	16.1	2.32 t-CO2/toe	37.4
Electricity & heat	141.1	8.26 t-CO2/toe[5]	1165.5
Direct emission	1124M t-CO2		
Indirect emission	1166 M t-CO2		
Total emission	2290 M t-CO2		

Calculated by author

2.2 Industrial fabric analysis

Since China opened to the outside world, the industrial fabric changed a lot. The share of gross output from state-owned and state-holding enterprises change from almost 100 percent to 32.3 percent in 2004 and meanwhile, the share of foreign funded and private enterprise reached 31.4% and 16.5% respectively (NSB 2005a) as shown in Table 2.3.

Table 2.3 Contributions of different ownership enterprises to gross industrial output value in 2004.

	Output (US$ billion)	Share (%)
Total	2283.2	100

[3] Based on Table 1

[4] Emission factors of coal, oil and natural gas come from Zhou (2003).

[5] It is assumed that thermal power plants are all coal-fired ones. In 2003, China produced 19105.8 GWh of electricity, and 82.7% came from thermal power plants. The efficiency of electricity generation and heating by power stations was 39.25% (China Statistical Yearbook 2005 page 262). So the emission facto of electricity and heat can be estimated at 3.93/39.25%*82.7%=8.26 t-CO2/toe

Of the Total		
State-owned and State-holding Enterprises	804.5	35.2
Of the Total		
Collective-owned Industry	129.1	5.7
Share-holding Cooperative Enterprises	48.1	2.1
Share-holding Enterprises	985.2	43.2
Foreign Funded Enterprises and Enterprises with Funds from Hong Kong, Macao and Taiwan	717.6	31.4
Of the Total		
Private Enterprises	376.8	16.5

Source: NSB (2005a) Page 488

Only annual sales income over US$ 0.6 million non-state-owned industrial enterprises are taken into account

Exchange rate US$1 = 8.2 *yuan* RMB

The total industrial value-added in 2004 was US$ 766 billion. Among it US$668 came from all state-owned enterprises and non-state-owned enterprises above designated size accounted for 87%. 13% of industrial value-added come from those non-state-owned enterprises that annual sales income less than US$ 0.6 million. Normally those enterprises aren't taken into account in the Industrial Chapter of China Statistical Yearbook.

There were 219,463 industrial enterprises with 61 million employees in 2004. Among them, 23,267 are large- and medium-sized enterprises[6] with 22 million employees. More than 60 percent of employees worked for small-sized industries.

The contribution of light industry and heavy industry to total industrial value-added is 32 percent and 68 percent respectively. In other words, more than two third of industrial value-added comes from those energy-intensive sectors such as steel, cement and petrochemical.

When coal mine accidents happened or serious water pollution events happened, most people outside of China think that is because of the informal plants' operation. The problem of informal plants is a difficult and complex issue in China. In different cases, the informal plants or illegal plants have different means.

If a plant has registered at authorized organization of business administration, it is a formal plant. But a formal plant should operate with other licenses or certifications. For example, an enterprise with the business of coal mining, besides having business

[6] There are main three standards to define large- and medium-sized enterprises. First is taking the product production capacity as a standard such as steel industry. Large steel plants are with steel production capacity over 600,000 tonnes and small ones below 50,000 tonnes. Second is taking the installed equipment capacity as a standard such as power industry. Large power plants are with generator capacity over 300MW and small ones below 50MW. Third is taking the fixed assets as a standard such as machinery manufacture industry. Large plants are with fixed assets over 50 million yuan RMB and the small one below 15 million yuan RMB.

certification, the plant should have another four licenses that are resource exploration permit, safety production license, coal production license and manager qualification certification. Without any of them, the plant operates illegally. There are more than 24,000 small coal mines in China. Most of them are formal ones but operate illegally. Some plants are required to have a pollutant discharge permit for operation. Large amounts of small-sized plants shut down by the government for energy efficiency and pollutant abetment purposes are formal ones. Their revenue is an important part of local fiscal income. That is why the central government met resistance when shut them down. That is also caused debates in terms of legal issues.

Definitely, there are informal plants in China. But it is very difficult to learn the real situation of them.

Summary of this section: Industry plays a very important role in China. It contributed 45.9% of GDP[7], consumed 70% of energy[8], and emitted 60.9% of CO2[9]. The share of gross output from state-owned and state-holding enterprises change from almost 100% to 32.3% in 2004 and meanwhile, the share of private enterprise reached 16.5% in 2004. Foreign funded enterprises and enterprises with funds from Hong Kong, Macao and Taiwan contributed near one third of GDP.

[7] Includes electricity generation sector.
[8] Coal equivalent calculation
[9] Includes indirect emission from electricity consumption

3. Energy efficiency of energy-intensive industrial sectors

China energy-intensive industry is the focal point when energy related issues are discuses since its huge outputs, fast growth trend and low energy efficiency. This section will focus on several energy-intensive products to summarize their development trends; compare the energy intensity of main products with state-of-art level in developed countries; and explore the common issues that affect the energy efficiency in Chinese industry.

3.1 Target-driven development

The China's economy development is driven by development targets set by the government. The 'fourfold target', 'building well-off society' and 'being a medium developed country by 2050' make China keep the economy fast growing to achieve these targets. Huge amount of investment goes to construction of highways, railways and new buildings that promotes the market demands increase tremendously on cement, steel, aluminum and other energy intensive industrial products. Figure 3.1 shows the main energy intensive products' output that indicated the fast growth appeared around 2002. It made power shortage first at the end of 2002, and followed by oil shortage and coal shortage as well.

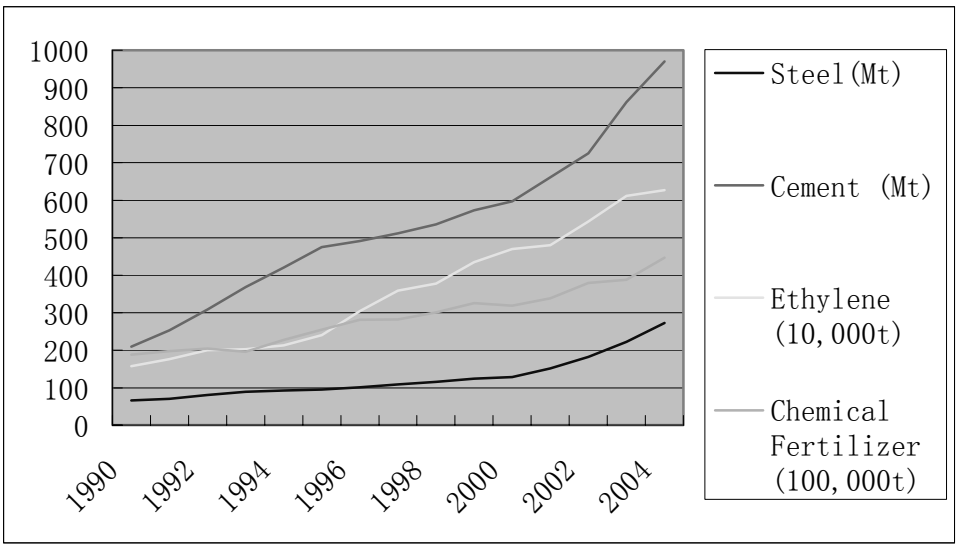

Figure 3.1 Output of several energy intensive products
Source: NSB (2005a) Page 514

At the end of 2003, NDRC and administrative departments issues three documents for stopping the blind investment on steel, aluminum and cement sectors respectively. The state Council asked the local governments to report the situation in their regions by the end of February 2004.

By reviewing the history of China's economic development, there is a phenomena appears periodically. The growth seems follow up the way of over hot – macro control – slow down – release control – over hot. The phenomenon is reflected well in the growth of steel and cement as shown in Figure 3.2. In the recent 20 years, the central government has made several decisions to limit the investment in different sectors to avoid capacity surplus. Sometimes the government order works well but sometimes doesn't. For example, in 1999 the central government asked all shaft kilns with diameter less 2.5 meters shut down for both energy efficiency purpose and slow down economic development , many shaft kilns were retrofitted to larger diameter ones because market had a strong demand on cement.

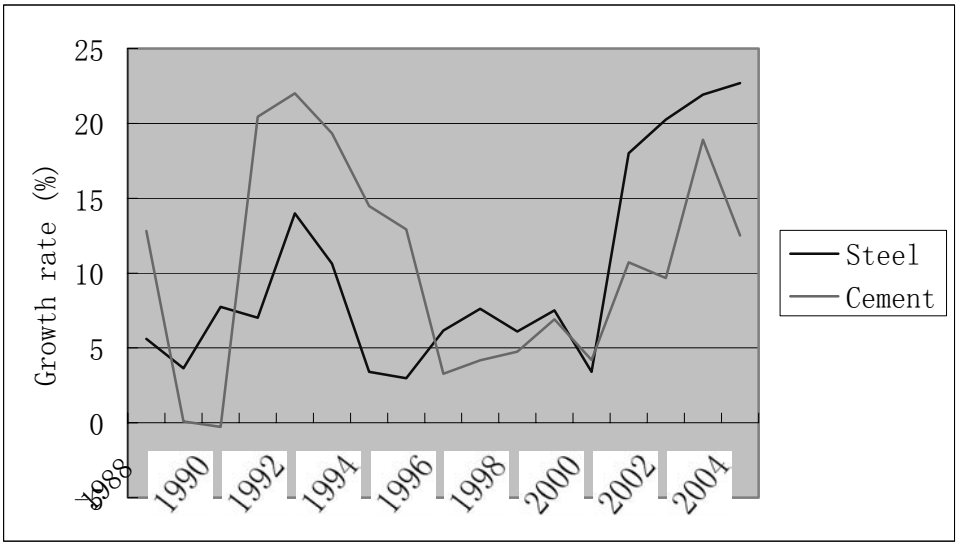

Figure 3.2 Steel and Cement Output Growth 1998-2004
Source: NBS (2005a) Page 514, NBS (2000) Page 454. Growth rate calculated by the author

Although the government adopts administrative method to promote or limit development in some aspects, the market force plays the decisive role. For example, after Beijing successful gained the bidding of 2008 Olympics, the municipal government asked all shaft kilns should be shut down by the end of 2003; Zhejiang provincial government used 23 million yuan or near US$ 3 million of public budget to subsidy those plants that close shaft kiln operation; Sichun, Huibei and other provincial governments prohibited the key construction project using cement produced by shaft kilns. There were still more than ten thousand shaft kilns in operation in 2003. But after the manufacturer's price of cement from NSP kilns decreased to 225 yuan per tonne (No. 32.5) in a region, all shaft kilns in this region started to shut down by themselves. But in another region, since strong demand, all shaft kilns operated fully because there was no enough supply from NSP kilns (Lei 2005)

Now, China is the largest producer of steel, cement, chemical fertilizer in the world. Its cement output took 45% of world total in 2004 (Price 2005), steel 23% in 2003

(CSA 2004), and nitrogenous fertilizers 25.5% in 2002 (CNCIC 2004).

3.2 Energy efficiency of industry

China's industrial energy efficiency has improved a lot since 1980's. But comparing to developed countries, its efficiency is still far behind of world advanced level. Table 3.1 shows the changes in energy intensity of main industrial products, the advanced levels of China and the world.

Table 3.1 Energy intensity of main products

Product	China 1990	China 2004	China advanced leave (company, year)	World advanced leave (year)
Steel (kgoe/t) (comparable)	697.9	491.4	472.5 (BaoSteel 2004)	452.2 (2000)
Cement(kgoe/t)	140.7	109.9		88.0 (2000)
Ethylene(kgoe/t)	1106.0	702.8	688.3 (SINOPEC 2004)	440.3 (2003)
Synthetic ammonia (kgoe/t)	940.1	828.8	788.9	--
Aluminum (kWh/t)	16,223	15,080 (2003)	--	14,100 (2003)
Oil refinery (kgoe/t)	105.7	72.7 (2003)	50.69 (Yangzi, 2004)	50.9 (2003)

Source: NDRC (2005a), SINOPEC (2005), Wang (2005) and EF (2004)

The achievements on energy efficiency improvement are gained by the following efforts:

- Implementing energy efficiency policies in industry. For example, the continuous casting technology was listed in the national technology guidelines for promotion of adopting for many years. The continuous casting ratio increased from 22.3% in 1990 to 82.5% in 2000 and 97.3% in 2004 (CSIA 2004, NRDC 2005). No open-hearth furnaces are operated in steel plants. A detailed discussion on policy issues is in the below sections.
- Introducing advanced technologies and know-how through bilateral or multilateral cooperation and international technical assistant projects. Using the low interest loans from Asia Development Bank to convert wet process to dry process in cement production in the 1980s introduced NSP kiln[10] on the first time to China. It can save 70kgoe per tonne of clinker comparing to the wet process (AIT 1997). The CDQ (Coke Dry Quenching) system can recover 2000kJ per tonne of coke, nearly 80% of the thermal energy of the incandescent coke. This technology was introduced when BaoSteel was built in the 1980s.

[10] New suspension preheater

- Diffusing efficient technologies through making equipment domestically. The high cost of importing technologies and equipment is one of barriers to adopting efficient technology broadly in China. For example, the investment of an imported 5-stage preheater/pre-calciner cement kiln with capacity of 4000 tonne per day was US$ 130 million in 1986 (ADB project). The energy conservation cost would be US$80/toe. Till 1990, China only had 13 NSP kilns (AIT 1997, CCN 2005). As China mastered the technology, the investment of a domestic made kiln with the same capacity is only one fifth of the figure. By the June 2005, China had more than 300 NSP kilns and most of them were built in recent five years.
- Co-benefit from new construction projects. Large amounts of new projects constructed increased the energy efficiency since most of them adopted advanced technology. Although the adopted technologies are not as good as world advanced ones, comparing the old plants, the energy efficiency have some improvements indeed.

Even great improvements have been achieved; there are still large amounts of potentials on energy efficiency improvement in industry.

3.3 Evolution of industrial energy efficiency

Although different plants and sectors have their specific problems affected their energy efficiency. Several common reasons for low industrial energy efficiency are among the various sectors such as small scale equipment, outdated production process and low efficiency of operation. These issues have existed for years, and many efforts have been made to deal with them, but they are still the problems.

- Small scale equipment

All energy intensive industrial sectors require large scale production equipment for increasing productivity and energy efficiency. The development also presents the trend towards the direction. The government promotes annexation and reorganization of enterprises to form large scale cooperation or cooperation group. This measure plays some roles on enlarge equipment scale. For example, several cement plants reorganized to form a large company, only large scale clinker kilns keep running and other small plants were closed to build milling stations for cement distribution. But in many cases, the annexation only enlarges the scale of enterprise, not scale of equipment. Figure 3.3 shows the scale mix of main equipment in China's large- and medium- sized steel plants. It indicated that most of equipment is small scale. There are only 5 blast furnaces with capacity over 3000 cubic meters each. The figure in Japan is 22 (CSIA 2004). Even those equipment adopting advanced technology, the average scales of them are still not large enough as shown the example in Table 3.2 and Figure 3.4.

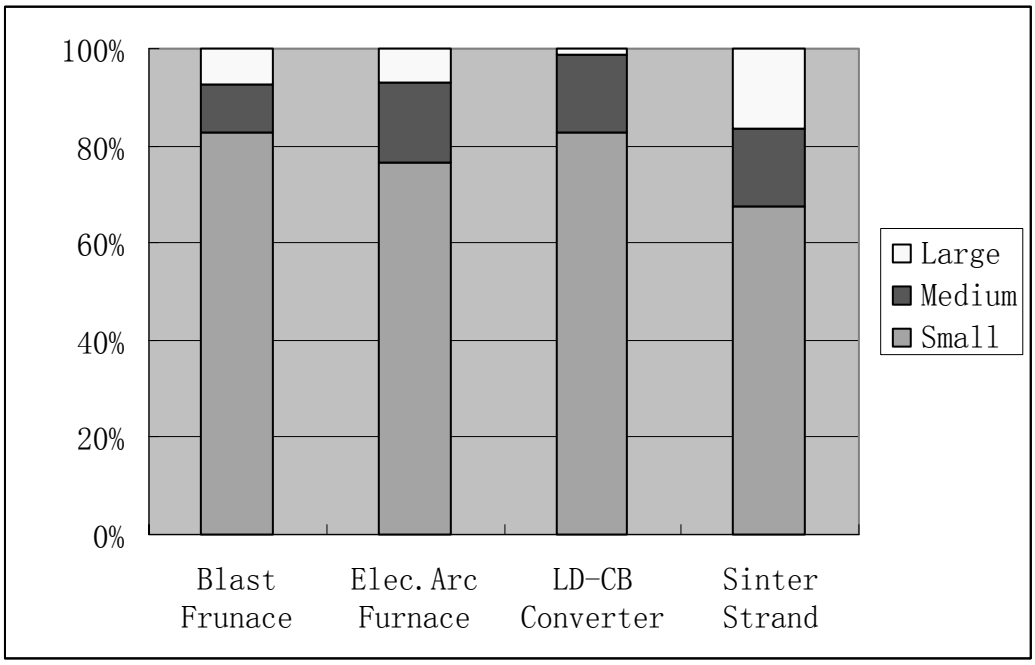

Figure 3.3 Scale mix of main equipment in China's large- and medium- sized steel plants.
Source: CSIC (2005)

Blast furnace: Large scale ≥ 2000 cubic meters

2000 cubic meters <Medium scale≤1000 cubic meters
Small scale< 1000 cubic meters

Elec. arc furnace: Large scale ≥ 100 tonnes

100 tonnes <Medium scale≤50 tonnes
Small scale< 50 tonnes

LD-CB converter: Large scale ≥ 300 tonnes

300 tonnes <Medium scale≤100 tonnes
Small scale< 100 tonnes

Sinter Strand: Large scale ≥ 1300 cubic meters

130 cubic meters <Medium scale≤90 cubic meters
Small scale< 90 cubic meters

Table 3.2 Operated NSP Kilns by 2002

Scale of kiln (t/d)	Number of kiln	Annual capacity (million tonne)
5000-7000	9	14.63
4000	10	12.40
2000-3200	76	51.83
700-1500	127	35.43
Total	222	114.29

Source: CBMIA (2005).

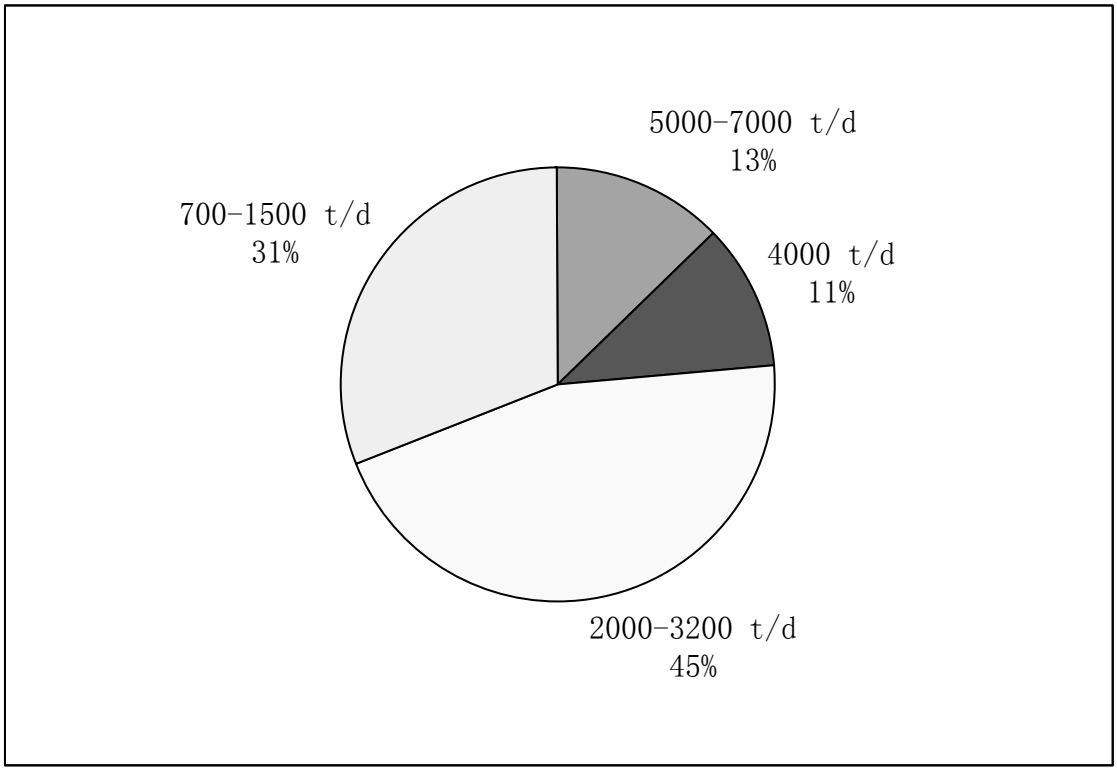

Figure 3.4 Capacity shares of various scaled of NSP kilns
Source: same as Table 3.2

- Outdated production process

The strong demand at market makes most invertors want to fast construction and fast output. But under the constrains of capital available, knowledge of advanced technology, and capacity of managing large project, most investment went to these projects with relative small investment, short construction period and non-backward process. This situation is presented typically in cement industry. Table 3.3 shows the composition of kilns in 1990, 2000 and 2003. It indicated that most new built kilns before 2003 are mechanical shaft kilns. Figure 3.5 compares the energy intensity of different sort of kilns. Most cement is made from those low efficient kilns as shown in Table 3.4. The cement produced by high efficient NSP kilns only accounted for 24% of total in 2003. The share increased to 32.5% in 2004 and 40% in 2005 but most cement was still produced by shaft kilns.

Table 3.3 Composition of kilns

Year	Number of kiln		
	1990□	2000□	2003□
Total	About 6000	7316	15033
NSP kiln	13	136	326
Mechanical shaft kiln	3241	5759	10430
Other low efficient kiln	Over 2700	1421	4277

Source: □ AIT (1997), □ EF 2004, □ Cui (2005)

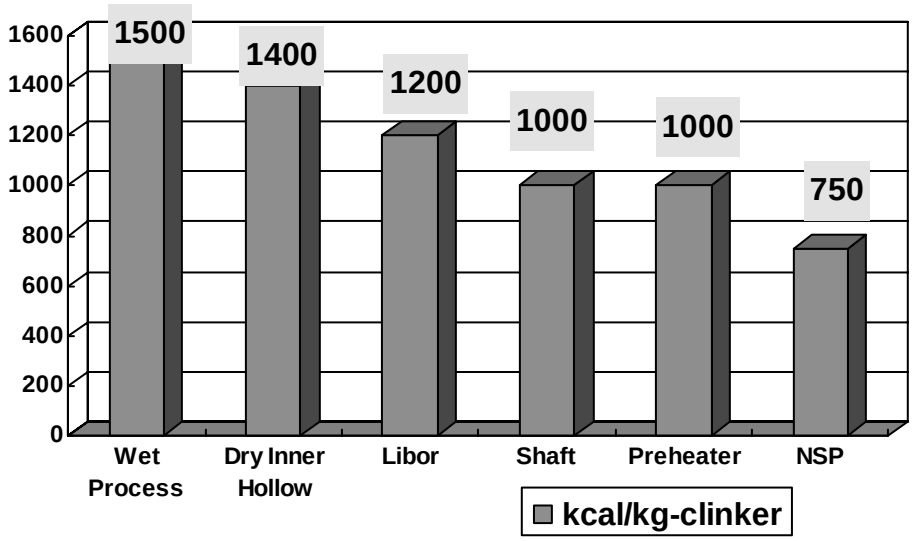

Figure 3.5 Comparison of heat intensity by type of kilns
Source: Di (2005)

Table 3.4 Cement output from various kilns

Type of Kiln	2003①		2004②	
	Output (Mt)	Share of Total Output (%)	Output (Mt)	Share of Total Output (%)
NSP/SP kiln	205	23.8	315	32.5
Other rotary	76	8.8	79	8.1
Shaft kilns	581	67.4	576	59.4
Total	862	100	970	100

Source: ① Cui (2005) ② Same as Table 5

- Low operational efficiency

Even large scale equipment and advanced technology adopted, the performance is not as good as it could be. This is a phenomena recognized by most industrial experts in China. But it is difficult to quantitative measure. The following factors are thought to low the operational efficiency.

- ✓ Low management level in most plants
- ✓ Unscheduled operation interruption
- ✓ Shortage of well trained staff

According to a survey conducted by China Petrochemical Corporation, it has 30,820 sets of transformers with total capacity of 4.6 million kV_A in operation. All

transformers are efficient ones but the load rate only 0.45 (SINOPEC 2005).

- Losses in trade-off on cost and efficiency

China is still a developing country. Many enterprises had to balance the cost and efficiency and chose a cheap technology in most of cases. For example, cement plants adopted technology using low temperature waste heat for power generation. If import all equipment from Japan, the electricity generated can reached 35kWh of one-ton clinker (Anhui Ninggou 2002), reducing the energy bill of the plant considerably. If using domestic equipment, the output less 30kWh per tonne clinker. From energy efficiency point of view, Japanese technology is better. Even a Japanese company -- Kawasaki Company completed a successful demonstration project in China in 1998; its technology and equipment have not gained the market share in China because of its high cost. Japanese equipment costs a company 18-22 thousands RMB or US$2,200—2700 per kW to build a set with the installation capacity over 6MW (Pan --). The cost of domestic technology is around 5,600-10,000 RMB or US$ 700-1,200 per kW. So, most cement adopted domestic ones.

- Difficulties on fuel switching and substituting

It is well known using coal could bring low efficiency than using natural gas such as ammonia production. China has modest space to switch coal to other higher efficient fuels. Meanwhile, burning waste is another option to improve energy efficiency in many countries. For example, steel plants burn recycled plastic in Japan, and cement plants burn waste in European countries. But in China, most waste plastic are used for making large amount of low quality but cheap plastic products at small plants. The government is not sure controlling dioxin emission if cement kiln burning waste, the fuel substitution is not a choice for energy efficiency in China.

Summary of this section: Energy intensive industrial sectors developed very fast during the tenth-five-year plan period (2001-2005). The energy intensities for main energy intensive products have decreased a lot but still high than that the world advanced levels. Efforts on enlarging equipment scales, phasing out backward production process, and improving management should be made to improve energy efficiency in industry.

4. Review of energy efficiency policy for industry

Chinese governmental authority has issued several energy efficiency laws and policies to build a favorable environment for whole society to improve energy efficiency. The main documents include Energy Conservation Law, Policy Outline for Energy-Saving Technologies, Cleaner Production Promotion Law, Supervisory Method of Electricity Consumption Conservation and Energy Efficiency Standards. This section reviews the history of energy efficiency policy development and summarizes the overall goals for energy efficiency improvement.

4.1 Tracking energy efficiency policy

China's energy efficiency policies experienced a transition process from plan oriented to market oriented. The driven-force for energy conservation also changed from solving energy shortage to solving local air pollution to sustainable development which combines the issues of long term energy shortage, energy security and environmental quality. As a developing country or non Annex-I country of Kyoto Protocol, China has no commitment to lower GHG emission. GHG emission reductions achieved through energy efficiency improvements are by-products, or ancillary benefits, of EE policy. Through the following chapter reviewing several specific energy efficiency policies, it is clear that no any of these policies takes CO2 emission reductions as the objective. Overall, however, energy efficiency has lowered the growth in GHG emissions, as strong energy demand keeps pushing emissions up.

Plan-oriented stage: later 1970s to early 1990s

China's energy efficiency policies started at a central planning system and extreme shortage situation in the late of 1970s. When the nation got rid of internal political chaos and planned to develop its economy, the nation faced a very serious energy shortage. Energy supply and transportation capacity limitation became a bottleneck to economic development. A lot of industrial enterprises only operated four days per week since there was no sufficient energy supply. Although the government made some policies or regulations for energy efficiency improvement, such as energy consumption quota system, the most attentions were paid to energy resource development.

The energy efficiency policies in this period are with three characteristics: government leading investment, focusing on state-owned industrial enterprises and favorable fiscal policy for efficiency projects.

Towards market manner: early 1990s to later 1990s

Since 1993, the nation started to convert from a planned to a market economy. Except for petroleum, China released the shortages from coal and power. Private enterprises

played more and more roles in the national economy. The government had lees impacts to state-owned enterprises than it before. But the environmental problems caused by a national self-sufficient, coal-dominated energy strategy became more serious. All these changes made the government to explore using more market manners and legal procedure for energy conservation. The government wanted to get environmental benefits by energy efficiency improvement. Many policies and best practices were introduced from outside, such as ESCO, efficiency labeling and DSM/IRP. Meanwhile, government cancelled all favorable fiscal policies for energy efficiency project, put the governmental expenditures for energy efficiency to a new established company called CECIC (China Energy Conservation Investment Cooperation) and ask CECIC manage and operate the investment on the basis of business, made energy conservation law and put it to a legal process.

The energy efficiency policies in this period are with another three characteristics: tentative, instructional and pilot. Since this is a transitional and preliminary learning process, on the one hand, energy efficiency policies used under planned condition cannot work very well for some aspects, and on the other hand energy efficiency policies used under market conditions haven't been made in many areas and sectors.

Market-oriented stage: since entering 21 century

Several big changes happened recent years pushed the government to rethink how to promote energy efficiency improvement under the conditions of market economy, to emphasize energy conservation and energy conservation in industry. These changes include:

- Energy-intensive industry expanded faster than ever before;
- A quick transition from an energy surplus to an energy shortage situation, even in the case of coal;
- The shortage is serious in some regions sometimes;
- Fast increases in oil imports received worldwide attention.

Influenced by the previous stage, energy efficiency policies in this period focused on regulating energy-consuming equipment manufacturing including appliances, motors, boilers, transmitter and other energy using industrial equipment by implementation of energy efficiency labeling and norms. A sort of equipment can not sell at market if it fails to meet an energy efficiency norm. The government hoped to increase energy efficiency by providing more efficient products to the industries and customers.

The energy efficiency policies in this period focused more on introducing policy measures from other countries and demonstrated in China, for instance, European-style Energy-Efficiency Agreements (EEAs) and USA-style governmental leading role on energy conservation.

At the 5th Plenary Meeting, the Sixteenth National Congress of the Communist Party of China held in October of 2005, building an efficient society was set as a general

target for China's development. This decision is meant to have a great impact on energy efficiency improvement.

4.2 Overall goals for energy efficiency improvement

The general goals for energy efficiency improvement worldwide can be summarized as the following items:

1. Lower pressure on energy infrastructure or solve energy shortage partially: it is the main driving force when a country is faced with short-term energy supply shortages.
2. Lower cost of products or enhanced competitiveness: it receives more attention when energy prices are high and in sectors with high energy costs.
3. Improve local environmental quality.
4. Reduce GHG emissions.
5. Contribute to long-run sustainable development.

Different countries have their one leading goal with others as associated goals in specific period. Table 4.1 highlights the main goals of China's energy efficiency policies over time.

Table 4.1 Leading goal for China's energy efficiency policies in different period

Goal	Before 1993	1993-1999	2000-2005	Beyond 2005
Lower pressure on energy infrastructure	Yes		Yes	Yes
Competitiveness				Yes
Local environmental quality		Yes	Yes	Yes
Reduce GHG emissions				
Sustainable development				Yes

Most products made in China are cheap at international market or bilateral trade since the very low labor cost. Improving energy efficiency for lowing cost further played a modest role on increasing competitiveness of Chinese products at international market, but it has a great impact to competitiveness of products at domestic market, especially the products from energy-intensive sectors. For example, more than half of the cost of cement production is spent on energy consumption as shown in Figure 4.1 (GDF 2005). In that sense, improved competitiveness through energy efficient decisions was in businesses self-interest, and not the goal of government's energy efficiency policies. As China jointed the WTO and the trend of globalization, Chinese government has put the competitiveness as one of priorities.

When explaining the importance and pressure of building efficient society, Mr. Ma Kai, the minister of National Development and Reform Commission (NDRC) pointed out that releasing resource restriction, reducing environmental pollution and improving the performance of enterprises are the top three considerations.

China has no legally-binding commitment to lower its GHG emissions under the Kyoto Protocol. GHG emission reductions through energy efficiency improvement are a mere by-product of energy efficiency policy, or other policy goals such as renewable energy development. Although renewable energy is recognized a good solution worldwide to global warming or GHG emission reduction, there is no reference to climate change or GHG emissions in the law that became effective on 1 January 2006 ("Renewable Energy Law of People's Republic of China").

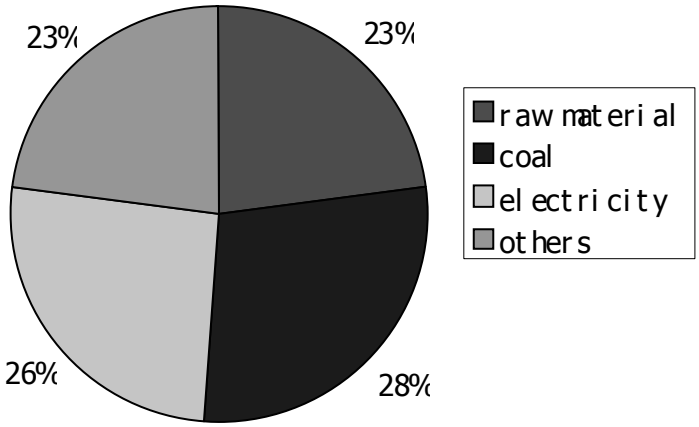

Figure.4.1 Distribution of cement production cost of general plants

Source: GDF (2005)

However, in the official document called "Suggestions for the eleventh five-year national economic and social development plan" passed by the 5th Plenary Meeting, Sixteenth National Congress of the Communist Party of China held in October of 2005, there is, for the first time, a sentence mentioning the need to "pay attention to GHG emission" (CCPC 2005). The article 19 on enhance the environmental protection under the section of building resource efficient and environmental sound society of the document, it indicated that integrated measures will be adopted for environmental protection of large- and medium- scaled cities; to enhance the pollutant treatment for industry; to speed up the treatment for SO2 emissions from coal-fired power plants; to pay attentions on control of GHG emission; and to find proper ways to deal with municipal waste and hazardous waste. Although there is no specific target, implementing steps and monitoring procedure for GHG emission reduction, it is a new delivered message and one and only Chinese official document up to now to mention controlling GHG emissions.

4.3 Measures for energy efficiency improvement in industry

China's energy efficiency policies and measures for industry can be clarified into three sorts: first sort is general policies or regulations which provide the principles and guidelines to all sectors including industry; second sort regulates specific

products or energy-consuming equipment which could be used in industrial sector or other sectors; third sort focuses on specific energy item, or specific sub-sector of industry or specific energy efficient technology. Some policies worked very well in a specific period and no more implemented now. Some policies had a long period impact. Some policies were replaced by the new ones.

Before 1992, the state-owned enterprises played a dominant role in the national economy. These enterprises were controlled directly by central and local governments. The governmental authorities had a great impact to the enterprises' managers. The energy efficiency policies made in this period were typical of a planned economy, mainly focused on controlling and reducing energy consumed by industry to solve the shortage problem, and to lower the negative impacts of blackouts on the building sector. Main energy efficiency policies and measures issued before 1985 included:

- Making the principle of paying equal attention to resource development and energy conservation;
- Implementation of energy consumption quota system for all industrial enterprises;
- Instruction of reducing direct oil combustion issued by the State Council;
- Instruction of electricity conservation issued by the State Council;
- Instruction of petroleum conservation issued by the State Council;
- Instruction of coal conservation issued by the State Council;
- Energy conservation became one of components of national developing five-year plan in the first time in 1981;
- Issued a document with 58 articles to regulate the efforts on energy conservation
- Capacity building for industrial enterprises through establishment of three-level energy management network and implementation of energy consuming supervision system;
- Set up energy conservation service centers at various local levels and energy-intensive industrial sectors;
- More public budgets for energy efficiency project. During the sixth five-year plan period (1981-1985), 3 billion *yuan* RMB or US$ 350 million from government expenditure were invested for energy efficiency projects (SETC 2004). It accounted for 0.4% of government expenditure during the same period[11].
- Low interest was applied to the loan which used for energy efficiency improvement projects. 8.2 billion *yuan* RMB or US$ 1 billion loan invested on energy conservation project combined with government expenditure. The annual interest was 2.4% which was 50% lower than that of general commercial loan (SETC 2004).

After the development of non-state-owned coal mine enterprises, the country was relieved from coal shortage in the late 1980s, but not from electricity and oil. Although the non-state-owned enterprises developed a lot, the government still kept the impacts to large and state-owned industrial enterprises. The governmental energy

[11] Total government expenditure was 748 billion yuan RMB from 1981 to 1985 (NSB 2000).

efficiency policies were implemented by state-owned enterprises. The energy efficiency activities focused mainly on equipment and production process retrofit and improving the energy management at state-owned enterprises for lowering pressures on energy infrastructure further and keeping the economic fast growing. The main energy efficiency policies and measurements issued from 1986 to 1993 included:

- Regulations on energy conservation management (temporary) (1986);
- Issued several energy efficiency norms and design criterions for energy consuming equipment manufacturing. The manufacturer has obligations to meet the norms;
- Continue to invest energy efficiency projects at state-owned enterprises. The total investment reached 36 billion *yuan* RMB or US$ 4 billion from 1986 to 1993;
- Energy conservation award presented to the outstanding state-owned enterprises;
- Prize for energy conservation awarded to outstanding staff in state-owned enterprises could be accounted into production cost for paying less tax;
- Import tax exemption for importation of energy efficient and equipment;
- Income tax exemption for projects that use advanced efficient technologies are exempted from income taxes for the first 3 years
- Government subsidy low interest loan for energy conservation project (30% lower), technology demonstration project (50% lower) and pay the bank out of pretax income (before 1994)
- Governmental leading role on efficient demonstration project construction.

Along with the process of building market economy, Chinese governmental authority tried to explore using market forces to promote energy efficiency. Some measures adopted during the planned period are no longer effective For example, as new production capacity installed the domestic market turned from seller's one into buyer's one, enterprises wanted to lower production cost as possible as they can for increasing competitiveness. The policy that allowed enterprises put prize for energy conservation into production cost was not attractive to enterprises, and no low interest loans were applied to energy efficiency project since the national financial system reform in 1994. The new energy efficiency policies and measurements issued from 1994 to 2000 included:

- Promote advanced efficient technologies through issuing 'guidance catalogues for technologies of comprehensive utilization and investment in energy conservation' to provide investment direction for enterprises and financial organizations;
- Energy Conservation Law of People's Republic of China became effective on January 1st 1998. The law built a legal framework and guidance to all activities related to energy efficiency.
- Shutdown the small-scaled energy intensive industries to prevent wasting resources and emitting pollutant;
- Issuing policy outlines for energy-saving technologies;
- Key energy consuming entities are required to set up an energy conservation

management system on a mandatory base.

- Regulations on electricity consumption conservation;
- To build trial ESCOs (referred to as EMCs – Energy management company – in China) based on the original energy conservation service centers that built during the planned period;
- To build energy conservation information dissemination center to promote information exchange on best available technologies.
- Conducted DSM/IRP (Demand-side Management/Integrated Resource Planning) pilot projects.

Reviewing the implementation of energy efficiency policies and measures in this period, people found that the energy efficiency improvements have been lower than expectations and than past periods' achievements (SETC 2004). The following reasons are proposed for this outcome:

- As they became relieved from energy shortage, people paid less attention to energy conservation than they did before;
- During the transition process, the old system built under planned economy conditions was broken but the new system worked under market economy conditions has not been built. On one hand, the government hasn't found the effective policy measures to promote energy efficiency improvement. On the other hand, the industry lost the guidance from policies.
- Although several policies and measures were to take advantage of the newly introduced market economy, there was no change in associated regulations or no supporting policies, making it difficult to implement them. For example, when EMCs provided services to enterprises, the accounting system did not allow the reimbursement of investments through shared savings.

After a detailed analysis on market failures and policy barriers on energy efficiency improvement, Chinese government insisted to go forward on adopting market measures to promote energy efficiency. Since entering 21st century, the government continued to take advantage of market forces and legal framework to enhance energy efficiency improvement. The new issued or affected policies related energy efficiency in industry included:

- Clean Production Promotion Law affected on January 1st 2003.
- Environmental Impact Assessment Law affected on September 1st 2003. It requires all new construction projects (including retrofit projects) should include an environment impact assessment report in project feasibility study report. If new proposed construction projects adopted low energy efficiency or backward technologies, they cannot pass the environment impact evaluation and get approvals for start up.
- Energy-consuming equipment (design) standards implemented to more industrial equipment such as boilers, motors, fans, pumps and transformers.

- Pilot energy efficiency voluntary agreement for steel industry.
- Energy conservation planning for tenth five-year plan period.
- Issuing policy outline for energy-saving technologies for the tenth five-year plan.
- China medium and long term energy conservation plan.
- Support the R&D activities on key energy efficient technologies.
- TOU (time of use) tariff and two-part tariff are used for industrial enterprises, in an aim to encourage lower electricity use during peak and avoid over capacity installation.

2006 is the first year of eleventh five-year plan period. Based on experiences of the last five years, China has decided to establish a recycling economy and to aim for an efficient society. More new efforts will be made on improving energy efficiency as a result. In the industrial sector, the following measures will be adopted in the near future:

- To establish a China top-1000 energy-intensive enterprises management system to monitor and cut their energy consumption;
- To enlarge energy efficiency voluntary agreement activity in the top-1000 energy-intensive enterprises based on the pilot project led in the steel industry;
- To have a preliminary idea on introducing an energy tax. But there are many uncertainties to implement it.
- To revise the Energy Conservation Law for better implementation under market conditions.

Summary of this section: Energy efficiency policy in China experienced the changes from planning oriented to market oriented. Many issues, except GHG emission reduction, are driven force for energy efficiency improvement. GHG emission reduction is a by-product of EE policy. The central government has decided to take the advantages of market force to promote energy efficiency improvement.

5. An analysis of energy efficiency policies implemented in China's industry

Above section gives the overall picture of development of China's energy efficiency policies and measures. This section will select several important policies and measures mentioned in the previous section and describe their scopes, contents, implementation status and other related aspects.

The following analysis will show that most policies' goals are expressed in qualitative rather than quantitative terms. Estimates of costs, savings, expected efficiency gains and CO_2 emissions are usually not featured, and the policy does not usually include monitoring and review. These are generally recognized as weak points in China's policy-making in energy efficiency.

5.1 Energy Conservation Law12

Energy Conservation Law of People's Republic of China (referred to here as Energy Conservation Law) is effected on January 1st, 1998. It includes 6 chapters or 50 articles which coved general provisions, energy conservation management, rational utilization of energy, technological progress of energy conservation, and legal liability. Within the territory of the People's Republic of China, any units or individuals must follow the law.

In the chapter of general provisions, it indicates that the law is formulated to promote energy conservation throughout society, improving the efficiency of energy utilization, achieving economic benefits, protecting the environment, securing national economic and social development, and meet the requirement everyday life of people. The governmental authority is in charge of making national energy conservation policies and energy conservation plan that is one of components of national economic and social development plan. The government promotes technical innovation and raises public awareness on energy conservation.

In the chapter on energy conservation management, it requests governmental authorities at various levels to allocate funding in their investment plan for energy saving purposes. Central government authorities must also strengthen the management for key energy-using entities that consume over 10,000 tce or 7,000 toe of energy annually. The authority will issue energy consuming standards or efficiency norms for equipment and products, and phase out backward and excessively energy-consuming products and equipment under use.

[12] www.opet.org.cn

In the chapter of rational utilization of energy, it prohibits any entity to produce, use, sell or hand over capital stock featured on a list of equipments that must be eliminated. The key energy-using entities must appoint professional managers for energy conservation and report on their energy use regularly to the government agency. For implementation of this measure, the government also issued another regulation called 'Supervisory Method of Energy Conservation for Key Energy Consumers'. This regulation clarified the industrial enterprises that consume over 7000 toe of energy annually should report their energy consumption to the central government directly. For those entities who consume less 7000 toe but over 3500 toe energy should report their consumption to the local government. The Statistic Bureaus at various levels are in charge of making a common format form for data collection. The detailed introduction on the regulation will present in later of this chapter.

In the chapter of technological progress of energy conservation, it gives the list of efficiency technologies for general purpose promoted by the government. It mentions that the central government will formulate a policy to support energy conservation demonstration and diffusion projects.

In the chapter of legal liability, it stipulates enforcement measures in cases of non-compliance. Non-compliance measures include financial fines, stopping operations and suspending certification of business, taking responsibility for any civil liability or criminal liability in accordance with relevant laws.

The Energy Conservation Law built a favorable environment for whole society. All activities related energy efficiency, such as making energy conservation policies, issuing energy efficiency standards, investing energy saving projects, are taken under the legal framework and guided by the principles.

Since its implementation from 1998, 'Energy conservation law' has made great contribution to normalize the administration of energy conservation and promote the whole society to save energy, to increase energy efficiency and economic benefit, to protect environment and ensure economically and socially sustainable development. For example, the energy intensity of GDP decreased tremendously during the last ten years of twenty century as shown in Figure 5.1.

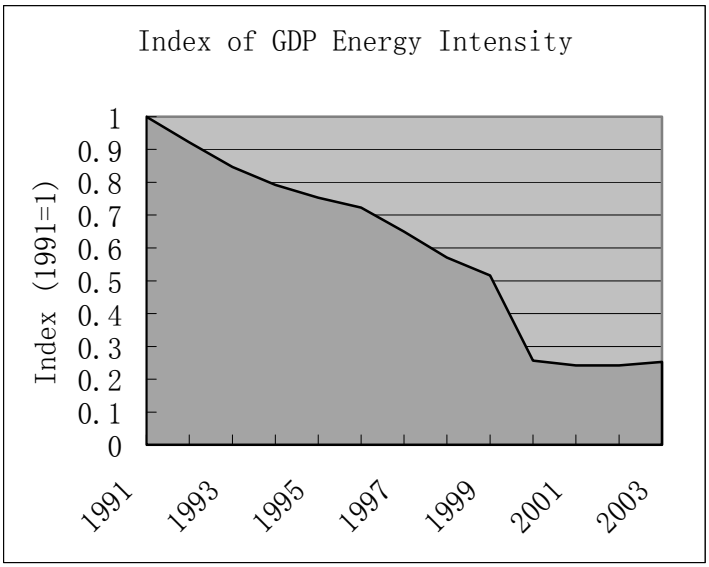

Figure 5.1 Energy intensity of GDP (1991-2002)
Note: Index is calculated by the author. Energy consumption data came from China Energy Statistical Yearbook (various editions). GDP of 1991-1992 came from China Statistical Yearbook 1995. GDP of 1993-2003 came from the bulletin on revision of GDP published by NSB. www.cpirc.org.cn (China Population Information Website)

But many changes have taken place after then in economy institution, government function, relationship between government and enterprise, energy conservation technology and legal system in the past. Additionally, the law itself is clear in principle but less feasible. Accordingly, many contents in this law couldn't match the social status and practical requirements in energy conservation. Therefore, it is necessary to adapt the law as early as possible. 'Energy conservation law' revision has listed in the national lawmaking schedule. The following key points will be addressed on amending the law (Zhao 2005):

- Combine government macro-control with market mechanisms;
- Combine management with incentive policies;
- Strengthen enforcement and punitive measures for infractions
- Attach importance to the control in the beginning
- Emphasize implementation measures and put the system design into operation.

5.2 Cleaner Production Promotion Law13

Cleaner Production Promotion Law of People's Republic of China (referred to here as Cleaner Production Law) is effected on January 1st, 2003. It includes 6 chapters or 42 articles which coved general provisions, realization of cleaner production, implementation of cleaner production, inducement measures, and legal liability. Within the territory of the People's Republic of China, any units or individuals engaged in activities relating to production or provision of services and their

[13] www.chinacp.com.cn

corresponding management agencies must organize and implement systems for cleaner production.

In the chapter of general provisions, it indicates that the law is enacted in order to promote cleaner production, increase the efficiency of the utilization rate of resources, reduce and avoid the generation of pollutants, protect and improve environments, preserve health and promote the sustainable development of the economy and society.

Comparing to Energy Conservation Law, Cleaner Production Law has more broad aspects. Energy is an important resource for production and energy consumption is a main source of pollutant emission. Improving energy efficiency is one of components covered by Cleaner Production Law.

In the chapter of realization of cleaner production, the law lists all responsibilities of governmental organizations to promote cleaner production. The responsibilities related to energy efficiency in industry include releasing guidance catalogues on cleaner production technologies, processes, equipment and products; issuing a directory of production technologies, processes, equipment and products to be eliminated within a time limit and establishing energy conservation labeling system.

In the chapter of implementation of cleaner production, the law regulates what the enterprises should do. Article 26 in this chapter points out that enterprises shall recover and utilize their own waste heat generated from the processes of production or transfer these waste to other enterprises or persons. Article 28 says enterprises shall monitor resource consumption and generation of wastes during the course of production and provision of services, and conduct cleaner production audits with respect to production and service procedures according to need.

In the chapter 4, the law indicates the incentive measures to cleaner production that include establishing a system to encourage and reward the outstanding enterprises in cleaner production; supporting research, demonstration and process retrofit for cleaner production by Special Technological Development Fund and Small- and Medium-Sized Enterprise Development Fund; reducing or exempting value-added tax to those products produced from waste and materials reclaimed from waste; and expenses incurred for cleaner production auditing and training may be booked as enterprise operating costs for tax reduction.

The law also sets liability for enterprises that act against it.

Cleaner Production Law made some progresses on operational aspects. For example, the Cleaner Production Audit Method (temporary) for better implementing Cleaner Production Law was issued on August 16th 2004 and came into effect on October 1st 2004, only 20 months after the law. Other detailed implementing methods at local

levels are also under development. But the law still lacks enforceable measures and needs more supporting regulations.

Let us consider waste heat for power generation project at a cement plant, as an example. It is well known that large amounts of waste heat are produced during clinker production. Most high temperature waste heat is used for pre-heating and pre-calcination of raw materials. A cement plant has planned to build a power generation facility using low temperature waste heat from its production process. This project can be a good one in terms of scope of cleaner production. Article 35 of Cleaner Production Law has a very clearly statement that "with respect to products produced from wastes and materials reclaimed from wastes, the taxation authorities shall reduce or exempt these from value-added tax in accordance with relevant national regulations." When trying to find whether the project could be eligible for a reduction or exemption of the value-added tax, we identified more issues that could be potential barriers to cleaner production, including:

- Is waste heat identified as 'waste'?
- What are the differences if the project is built and owned by different units: cement itself, a separate company or an ESCO?
- What are the differences if the electricity consumed by the cement plant itself or sold to the grid?
- And, last but not least, which government institution is able to provide guidance on the above?

Every year, the central governmental authorities conduct on-site visits to different regions and enterprises to learn the situation of implementation. Some checked enterprises are found to violate the provisions of the related articles. These enterprises are requested to pay fine and make rectification within a specified time limit. Although this enforcement mechanism promotes cleaner production a lot, it is difficult to evaluate the status of its implementation as no criteria were set for evaluation. For example, within the total 42 articles, there are about 19 articles prescribing the government's responsibilities and 12 articles regulating the enterprises' behavior. But articles in chapter of legal liability are all for enterprises. Enterprises only get punishment when they violate one or more of four articles. The said four articles have little connection with energy efficiency. So most people think the Cleaner Production Law as a promising policy for energy efficiency improvement, but actually it is difficult to evaluate its likely impact on energy efficiency improvement.

5.3 China medium and long term energy conservation plan

In November 2004, NRDC promulgated China medium and long term energy conservation plan (referred to here as the Plan). The Plan also can be thought as the eleventh five-year plan on energy conservation. Comparing to tenth five-year plan on energy conservation and resource integrated utilization, more efforts have been made

on the Plan and more quantitative targets were included in it. Making the Plan aims to promote energy conservation and energy intensity reduction throughout society; to remove energy bottlenecks; to build an energy efficient society; and to promote a sustainable social and economic development.

The Plan set up a general target for energy intensity of GDP improvement that lower from 2.68 tce in 2002 to 2.25 tce in 2010 and then 1.54 tce in 2020 per 10,000 yuan of GDP (constant price in 1990). If the target achieved, total 21 million tonne of SO_2 will be mitigated from 2003 to 2020 (NDRC 2005b). No CO_2 emission reduction is estimated by the Plan. However, a roughly estimation of CO_2 emission reduction can be done by the equation in the following box. The emission reduction will be totally 3.4 billion tonne of CO2 from 2003 to 2020.

If the energy intensity in 2020 reaches to 1.54 tce per 10,000 yuan, the annual efficiency improvement rate will be 3% from 2003 to 2020. The energy conservation capacity is expected to reach 1.4 billion tce from 2002 to 2020 (NDRC 2005b). In 2002, China consumed 1,011 Mtoe of energy and emitted 953 Million t-C (IEEJ 2005). The emission rate per unit energy consumption is 0.94 t-C/toe or 2.42 t-CO2/tce. If assuming the rate keeps constant, the CO2 emission reduction from 2003 to 2020 will be:

2.42 t-CO2/tce × 1.4 billion tce =3.4 billion ton-CO2

Industry is the main targeted sector for energy conservation. The specific energy intensity for main industrial products and energy efficiency for general power-consuming equipment are set also as shown in Table 5.1 and 5.2. In general, the government planned to raise the levels of performance of energy-intensive industrial activities to the international 1990s' levels by 2010, and international current level by 2020.

Table 5.1 Energy intensity target for main industrial products (national average level)

Specific energy consumption	Unit	2000	2005 (estimated)	2010 (planned)	2020 (planned)
Steel (integrated)	kgoe/tonne	634	532	511	490
Steel (comparable)	kgoe/tonne	549	490	480	448
Average of top 10 non-ferrous metals	kgoe/tonne	3366	3266	3217	3115
Aluminum	kgoe/tonne	6946	6717	6630	6454
Cooper	kgoe/tonne	3295	3037	2979	2800
Ethylene	kgoe/tonne	848	700	650	600
Large-scaled synthetic ammonia	kgoe/tonne	960	847	798	700
Caustic soda	kgoe/tonne	1087	1052	980	910
Cement	kgoe/tonne	127	111	104	90
Plain glass	kgoe/weight case	21	18	17	14
Architectural ceramics	kgoe/sq. m	7	7	6	5

Source: NDRC 2005b
1 kgce = 0.7 kgoe

Table 5.2 Efficiency targets for main power-consuming equipment (%)

	2000	2010
Coal-fired industrial boiler	65	70-80
Medium and small sized motor (design)	87	90-92
Fan (design)	75	80-85
Pump (design)	75-80	83-87
Air compressor (design)	75	80-84

Source: NDRC 2005b

For achieving the targets, the Plan listed key fields within industrial, transportation and building sectors and 10 key projects for energy efficiency improvement. Most attentions are given to energy-intensive sectors such as iron & steel sector and building material sector. The key projects related industrial energy efficiency included:

- Coal-fired industrial boiler (kiln) retrofit
- Wasted heat and pressure utilization
- Motor driven system improvement
- Enterprise energy system optimization
- Build a better energy saving service system

Along with another five key project in transportation and building sector, the total

energy savings during the eleventh five-year plan period (2006-2010) will reach 168 million toes according to expert's estimation.

The Plan also lists 10 implementation measures for guaranteeing the target achievement (refer Annex II). These measures can be grouped into four categories as following.

Policy guarantee: All policies and regulations related economic and social development be made in the future should take the energy conservation as a consideration. For example, the government will formulate policy measures of promoting development of low energy-intensive, high value-added and labor-intensive tertiary industry;

Financial support: Government will provide funding and subsidy or deducted loan to support energy-saving project construction, efficiency technology development and demonstration. Energy conservation investment guarantee will be provided by the authorized organizations.

Service system: Through building ESCO, energy-saving products certification issuing system and enterprises energy management system to help enterprises for energy efficiency improvement

Information dissemination: it includes incorporating the energy conservation into the education systems and technical training, releasing best practices on energy efficiency and so on.

Guided by the Plan, central governmental authorities produce a national five-year plan on energy conservation, which highlights conservation targets within 5-year period and measurement implementation for achieving the targets. A national annual plan on energy conservation has also been made to specify main activities of energy conservation, focal fields and specific working plan. For keeping consistent with central government and getting supports from central government, in some instances, energy-intensive sectors and local governments have drafted plans or project proposals to accomplish targets based on the national plan. For example, if a energy efficiency project is listed in the national annual plan, it could use public bonds with very low interest as investment.

5.4 Policy Outlines for Energy Conservation Technologies

In 1984, the former SDPC (State Development and Planning Commission), former SETC (State Economic and Trade Commission) and former SSTC (State Science and Technology Commission) issued jointly "Policy Outlines for Energy Conservation Technologies of China" (referred to here as the Outlines). The revised edition of the Outlines was issued in 1996. A 2005 edition of the Outlines is developed based on previous two editions.

Through issuing the Outlines, the central government intents to speed up building an efficient society by promoting an efficient industrial structure, an efficient products structure and a reasonable consuming structure. The new edition is inviting comments and suggestions from public and will be issued soon. The earlier two Outlines played an important role in the development, demonstration and diffusion of energy-efficient technologies in all sectors. In the case of steel making, continuous casting was listed in the 1996 Outlines. After ten-year efforts, the share of the continuous casting process increased from less than 40% in 1994 to 97.3% in 2004 (NDRC 2005a). We believe the new edition will also play important roles for the coming years.

The 2005 Outlines (draft) included nine chapters and covered most of technologies using in energy-intensive sectors and/or for producing energy-consuming products and equipment. The Outlines set targets for different sectors on energy efficiency improvement such as 15% of wasted heat from industrial kilns and furnaces must be used by 2010. The figure in 2004 was about 5% and 2.6% in 1990. The energy intensity (comparable) per tonne of steel will reach 480 kgoe in 2010 and 448 kgoe in 2020. The figure was 549 and 698 in 2000 and 1990 respectively. The new edition differs from earlier versions in that it mostly indicates, and encourages the use of, more efficient technologies. Earlier versions highlighted what technologies would be phased out within a fixed time schedule, where improvements should be pursued and what equipments were forbidden.

> 2005 Outline: To develop NSP kilns with capacity above 2000 tonne per day to replace shaft kilns and other inefficient kilns in cement industry.
> 1996 Outline: To develop NSP kilns with capacity above 1000 toone per day and to stop the construction of inefficient kilns in cement industry.

Annex III compares the contents of 2005 editions and 1996 editions of the Outlines. We can find although most parts of the contents are same, the new edition pays more attention to energy standards and norms while no energy standards and norms were mentioned in the early edition. In other words, the government intends to regulate the market through setting norms and standards and request business to implement them. For example, the energy norm for motors makes them sold at the market are all efficient ones.

5.5 Interim Regulations on Promoting the Adjustment of Industrial Structure

On December 2nd, 2005, the State Council issued "Interim Regulations on Promoting the Adjustment of Industrial Structure" (referred to here as the Interim Regulations). It includes 4 chapters or 21 articles which coved general provisions, directions and key points for industrial structure adjustment, guiding catalogue for industrial structure adjustment and supplementary articles. NDRC issued a detailed "Guiding Catalogue for the Adjustment of Industrial Structure (2005)" (referred to here as 2005 Catalogue) same day

as a supplementary document to the Interim Regulations. The industrial structure mentioned here means the three major three sectors' structure as First Industry, Second Industry and Tertiary Industry. The regulations cover a much broader range than included in the scope of this report. But it will have a great impact on energy efficiency in industry.

The Interim Regulations aimed to achieve sustainable development through supporting the development more efficient, clean and safe. Following the principles or directions of the Interim Regulations, the local governments will design measures to properly guide investment, so as to encourage and support the development of "advanced productivity" while limiting the growth and finally eliminating the out-of-date industries, as well as prevent blind and repeated investment. The relevant departments at central government level will formulate and modify policies on finance, credit, land use, international trade and other issues, so as to facilitate and push forward the structure adjustment.

The articles related to industrial energy efficiency include:

Article 6: Promote developing large-scaled enterprises of refinery, ethylene, iron & steel, cement and paper making;
Article 9: Emphasis on energy efficiency retrofits in iron & steel, nonferrous metals, petroleum chemical, coal, building materials and paper sectors. Lower the share of energy-intensive and highly polluting sectors' in the economy;
Article 11: Limit the exports of energy-intensive products and products based on pollution-intensive processes;
Article 14: Encourage building projects that contribute to energy efficiency improvement by giving the priority when government approves the project construction;
Article 15: Prohibit building such projects that no benefit to energy conservation and or production capacity surplus. For example, central government requests all commercial banks no loan would be given to any cement plant except with special permission.
Article 16: Stop the operation of energy-wasting equipment / projects.

The 2005 Catalogue listed 119 sorts of projects that the government supported, 84 sorts of projects prohibited and 145 sorts of production processes and 46 backward products that should be eliminated. Project proposals can't get approvals from the governmental authorities for construction if they are not in the supported list. The development and planning commissions at various levels are in charge of issuing permissions to new construction projects. If all governmental authorities follow up the Interim Regulations and 2005 Catalogue to issue the permissions to new built projects, meanwhile the enterprises upgrade the present operated facilities and phase out all backward process and products listed in the eliminated column of 2005 Catalogue driven by pressures from market and government, the energy efficiency of industry will be improved step by step. For example, the cement output in 2005 reached 1 billion tons, in which about 40% of the output came form NSP kilns with the energy

consumption of 750 kcal per kilogram of clinker. Other 60% of cement came from the kilns with the energy consumption of over 1000 kcal per kilogram of clinker. If all inefficient kilns replaced by NSP kilns, it would save energy 15 million toe annually.

Following the policy, local governments are making specific policies and regulations based on their own situation. For example, Zhejiang Province has decided to shut down all shaft cement kilns by 2007.

5.6 Supervisory Method of Electricity Consumption Conservation

Supervisory Method of Electricity Consumption Conservation (referred to here as Method) is affected on January 8th, 2001. It includes 6 chapters or 29 articles which coved general provisions, management of electricity consumption conservation, demand-side management, technology progress of power conservation, rewards and punishment.

The Method pointed that the governmental authority manages the power intensive products through issuing regularly ceiling value of the intensity for each product. Those consumers who consume over 3GWh annually or power load over 500kW must have power balance tests every two or four years. The realistic measurements on electricity saving should be implemented following the tests.

It is prohibited to produce, sale and adopt low efficient equipment and products which are in the official list of elimination. It is promoted to use efficient products identified by authoritative organizations. For example, if an enterprise adopted efficient electricity-consuming equipment, it would be free of paying the incremental capacity fee.

The Method promotes 11 categories of energy-efficient technologies, through DSM implementation. The ceiling values and advanced levels of energy intensity for electricity intensive products, such as aluminum, iron, calcium carbide, caustic soda, phosphor, ammonia, ethane, cement and steel, are listed in the annex of the Method.

5.7 Energy Efficiency Standards

There are several national standards of energy conservation auditing for industrial process and equipment which covered boiler, electric furnace, fired furnace, heat transport system, electric heater, cooling supply system, fans and network, steam heater, on-site electricity distribution system, air-compress system, pump and electric welding equipment. These standards were issued during 1994 to 1996. The standards of method to measure and calculate the savings were issued simultaneously. In 1999, a standard was issued to measure and use the waste heat resource from boilers' and furnaces' flue gases. Energy efficiency standard for medium- and small-scaled motor was issued in 2002 and for air compressor in 2003.

5.8 Supervisory Method of Energy Conservation for Key Energy Consumers

The former SETC promulgated "Supervisory Method of Energy Conservation for Key

Energy Consumers" as a supplementary document to the Energy Conservation Law on March 10th 1999. It requested any establishment with annual energy consumption of 10,000 tce and above to submit their energy consumption data of previous year by the end of January to central governmental body. Those establishments with annual energy consumption less 7,000 toe but over 3,500 toe should submit their data to provincial governmental bodies. The submitted data form included not only energy consumption data, but also energy intensity of main products and energy efficiency of main energy consuming equipment. The Supervisory Method prescribed that the governmental authorities at national and provincial levels should issue communiqué termly to release the establishment list and their energy consumption.

After the Supervisory Method came into effect as of March 10th 1999, the SETC and NBS (National Bureau of Statistics) conducted a survey of all key energy consumers (consumed 7,000 toe and above). The survey results showed that there were 7,283 enterprises with energy consumption of over 7,000 toe in 1997. They consumed 539 million toe of energy, i.e. 57% of the country's total energy use. Among these enterprises, 61% of enterprises came from 7 sectors. Besides power sector, the other six sectors are all energy-intensive industrial sectors such as steel, chemical, refinery, coal mining, building materials and petroleum sector (NBS 2000). In 2002, the energy consumed by these enterprises reached 573 million toes, 55% of China's total energy consumption that year (Liu 2004).

Although NBS had some data of 1998 to 2002 from these enterprises and conducted analysis on these data, these data have not been made public and no communiqué has been issued by the central governmental body since the Supervisory Method was implemented. Most of the analysis is focused on the energy intensity of sectors' value-added, and lacks analysis of the energy intensity of specific products. So the recent promulgated policies mentioned above are all based on 2000 data. This situation would make policies to address current situation very well. For example, the continuous casting ratio has reached 97% in 2004, the medium and long term energy conservation plan issued in 2005 still considered to increase the ratio.

5.9 Energy Auditing

Energy auditing in China started from beginning of 1990s while the Asia Development Bank (ADB) required all projects should conduct energy auditing if the loans for project came from ADB. Based on the practices, Chinese experts have developed a methodology and procedure of energy auditing for industrial firms. A national standard of "Enterprise Energy Auditing Technical Guidelines" was published in 1997. A pilot project started in 1999 to get experiences for setting up a regular national energy auditing system. But up to now, energy efficiency auditing has not been used widely by enterprises. Further, there are no requirement and management frameworks in place to identify the role of energy auditing for energy efficiency improvement.

5. 10 From energy conservation service center to EMCs

There were more than 180 energy conservation service centers with 3000 staff set by different areas and industrial administrations during the1980s. Following up the national, local and sectoral energy conservation plan, these centers got support from governments, provided technical services to enterprises and play very important roles in energy conservation under the planning

economy conditions. As China market economy progress and administration reform, most centers lost the support from governments. Because of shortage of capacities of marketing, most centers can't develop their business further and their roles are becoming less and less. A new form of service agency—EMC (energy management contact) has occurred in China follow up the development of ESCOs in other countries. Three EMCs have set up based on the energy conservation service centers to find the effective ways to promote energy efficiency under the market economy conditions in China. Till the first half year of 1999, these three EMC conducted 30 projects with the grant of 24.91 million *yuan* from EU and the total investment reached 34.98 million *yuan*. 24.91 million *yuan* has returned from those projects, in which, 9 projects has get all investment back and others are in the stage of benefit sharing. More EMCs will be built in the further.

ESCO business is in its preliminary stage in China. The government is trying to form an operational mechanism supporting ESCO business. Three demonstrative ESCOs, supported by WB/GEF and central government, fully operated under the conditions of market system and make progresses. This section will briefly describe "how ESCOs operate in China", highlight the barriers in the operation and summarize lessons learned from the operation.

Since identification of energy conservation as one of key components of national energy policy, many energy saving service organizations was set up during 1980s to 1990s providing technical services on energy efficiency business. Most of these entities were named "energy conservation center", non-profitable organizations and belong to governmental authorities in different regions and various industrial administrations. These centers played very important roles to increase energy efficiency from middle 1980s to 1990s. Most government leading energy conservation programmes and projects were assigned to these centers and conducted by the centers or with the assistances from the centers. By the end of 2000, there were more than 2000 centers in China. Although these "centers" renamed to "companies"; separated from governmental authorities and became to independent profitable entities, as China's transition from planning economic system to market economic system, these center met problems in their operation. For example, there was no government assigned projects with funds given to these centers; these centers lost business opportunities that used to be supported by authorities; and their staff often lack experience in running commercial businesses.

In 1996, supported by World Bank and Global Environment Facility, China started a project titled "WB/GEF China Energy Conservation Promotion Project". The project aimed at introducing the ESCO concept and operation mechanism to China, overcoming the barriers in investing energy efficiency projects and supporting ESCOs' operation in China.

The main task of this project is setting up three demonstrative ESCOs to establish some know-how in the operation of such business and to identify specific needs

towards the development of the ESCO business in China. Till the end of March 2004, the three demo ESCOs have signed 296 contracts with clients for energy conservation projects. Total investment reached 710 million *yuan*. 99% of projects are successful. ESCOs have started to build reputations among customers. The average investment for project increased from 950,000 *yuan* at early stage to 3 million *yuan* above. It is estimated the annual savings will be 857,600tce and CO2 mitigation 548,400 ton. ESCOs will receive totally 940 million *yuan* from sharing savings[14].

Up to now, there are more than 100 enterprises involved in ESCO business in China. The second phase of WB/GEF project has been conducted to continue to support ESCO operation. Using GEF grant of 22 million US dollars, China set up an ESCO guaranty fund to help ESCOs financing. Since most ESCOs in China are technical oriented small companies that lack of credit at bankers. It is difficult for them to get loans without guaranty from banks when they conduct energy efficiency projects. The fund is operated by China National Investment & Guaranty Co., LTD[15] that provide guaranty to ESCOs for getting loans from banks. ESCOs pay guaranty fee the (normally 1-2% of loan) to China National Investment & Guaranty Co., LTD.

Most people think ESCO would have a bright future in China, there are several barriers at moment to slow down the ESCO business development.

- Support from legal framework is not strong enough: Although Energy Conservation Law formed a legal framework to encourage energy efficiency, it presented normally a general principle and lacked exercisable measures. Other related regulations tried to make the law more operable as mentioned before, they are still shortage of details for implementation. For example, most regulation have a chapter of reward and punishment for good or bad performance on energy efficiency and give the right to authorities at sector and local levels to implement it, there is no specific articles to mention who will audit the enterprises and judge their performance on energy efficiency; how many enterprises the authorities should reward or punish every year; and where the budget comes from for conducting such kind of activities.

- Enterprise accounting system does not support the mode of “paid-from-savings”: one of innovations of ESCO is its financing institution. ESCOs finance energy efficiency projects to their clients. The customers’ debt payments are tied to the energy savings offered under the projects so that the customers pay for the capital investment with the money that comes out of the difference between pre-installation and post-installation energy use and other costs. But the payments paid by customers couldn’t be calculated as a part of their production cost. The calculation on depreciation of installed efficient equipment also has problems under current enterprise accounting system. All these issues put ESCOs and their

[14] www.cinic.org.cn

[15] www.guaranty.com.cn

clients a difficult position when they negotiated performance-based contracts.

- ESCOs lack the capacity of fund raising: Historically, the energy service industry is relatively young. Most Chinese ESCOs don't have enough capital to invest an efficient project by themselves, even a relative small project. ESCOs can't get loans from commercial banks because they have no collateral and reputation of records. Chinese banks, on paper, do not lack liquidity, but they are reluctant to loan to ESCOs. For fixing this issue, the first phase of WB/GEF project put part of project money into the three demonstrative ESCOs as a seed-investment. The second phase of WB/GEF project built an ESCO guaranty fund by using project grant that would increase capital tenfold. But comparing the great potentials of investment opportunities, the amount of capital is not a big number.

- Shortage of persons with ability to operate ESCOs: ESCO operation needs an integrated capacity including technical aspects, marketing, business plan making, financial affairs management, risks control and project management. At moment, the staff worked for ESCO in China has limited experiences on providing professional services to their clients. Even some of them have a better training on ESCO's operation; they still need learning by doing. Up to now, there are no foreign ESCOs from developed countries to set up joint venture ESCOs or engage the ESCO business in China.

For promoting ESCO business, more efforts should be made to deal with the following issues in China

- It is urgent to issue operable energy efficiency regulations that will give the guideline the business follows up.

- Find a solution to harmonize the conflict between accounting system and ESCO financing way.

- Seed-investment plays a very important role at the early stage of ESCO business. A professional ESCO guaranty fund or a mechanism that can provide guaranty to energy efficiency projects is necessary for ESCO doing business.

- It is valuable to spend more money and time on training programs to educate public and professionals learning more about ESCO and ESCO business.

- Demonstrative ESCO operation under market conditions is a promising way to start ESCO businesses. Many barriers and problems could be identified from its operation.

5.11 Demand Side Management

A pilot DSM project has been conducted at Shengli Oil Field since 1997. This project received

strong support from central government and covered load adjusting, loss reduction for distribution system, efficiency improvement for final users, TOU tariff adopting and many other measures. The payback time for all investment is less than two years and saved more than 200 GWh in 1997-1999. The successful DSM programs indicated that there is a large potential to improve electricity efficiency and supply reliability in China. Focusing on specific technology utilization is one characteristic of most DSM programs in China. For example, the Shanghai Utility promoted hotels adopting cool storage air condition system, Liaoning Utility focused on electric furnace upgrading in metal processing plants. TOU tariff adoption also promoted DSM programs in China. For example, Beijing has built 32 projects of cooling storage. In the summer of 2005, they reduced peak load by 24.3 MW (Wang 2005). Shanghai reduced peak load by 3900 MW in 2005 by installed efficient bulbs, cooling storage air conditioners and other measures. (Le 2005).

As the release from power shortage, DSM program received less attention from government and utilities. Most measures adopted around 2000 were load shift ones like cooling storage air condition system as adoption of TOU tariff and since utilities can get benefits from load shift. Some regions even promoted consuming more electricity. For example, if no gas fired water heater and no gas fired or coal fired stove were installed at a household; and all energy services provided by electricity, this household can get a very low electricity price in some regions.

Power shortages have reoccurred since the end of 2002, bringing DSM back to the front in many regions. NRDC announced local governments and power grid cooperation to enhance the management on electricity consuming side in 2003[16]. A kick-off meeting was held on December 22nd, 2005 on making DSM implementation method and DSM planning. The government intends to set up a long-term mechanism on DSM through policy-making. These two official documents will be available in April and October 2006 respectively[17].

Supported by regional utilities, several DSM projects have been conducted, especially in the regions which are in serious power shortage like Jiangsu and Fujian Province. The local government and utility made great efforts to low power load. Fujian government provided subsidy to customers who installed cooling storage air conditioners. The customers who installed the system in 2004 got subsidy of 200 yuan/$kV_{A.}$ The customers who installed the system in 2005 got subsidy of 100 yuan/$kV_{A.}$ The customers who upgraded their air condition system with cooling storage technology in 2004 got subsidy of 500 yuan/kV_A and upgraded in 2005 got 500 yuan/$kV_{A.}$ Meanwhile, the tariff for the system is 50% lower than the valley load tariff (QZWB 2005).

[16] NDRC's document.
[17] www. sdpc.gov.cn

Summary of this section: China has a series of policies for energy efficiency improvement. Some policies are legal documents, and some belong to administrative regulations. Great attentions are given to industry sectors, especially to energy-intensive sectors and large energy consuming enterprises. Most policies are clear in general principles, but shortage of implementing arrangement. Even some policies address very detailed issues, like listing all technologies what government supported and what government prohibited, they are guidelines or directions rather then measures.

Most policies are qualitative rather than quantitive. It is difficult to evaluate the effectiveness of the various policies. Financial support to energy efficiency improvement is one part in many policies. But no policy indicates how strong the support is. Policy itself and funding of policy is always separated.

Since China has no commitment to low GHG emissions, no policy takes GHG emission reduction as a target. Although it is very clear that how many energy would be saved through energy efficiency improvement by the targeted year, no CO2 emission reduction is estimated within the official documents. CO2 emission reduction is only a by-product of these policies. .

6. Alternative policy tools

International cooperation on energy efficiency plays very important role when policy making. China is willing to learn the experiences from other countries to improve the policy making and implementation. This section will introduce the several alternative policy tools that are under consideration and will be implemented in the future.

6.1 Energy-efficiency agreement (voluntary agreement): pilot projects

An US based foundation -- Energy Foundation supported a project to investigate use of new industrial sector energy efficiency policy mechanism in 1999. Voluntary agreement was selected as a pilot policy for China industrial energy efficiency policies project. The goal of this project is to develop a policy framework and associated implementing regulations required to establish a comprehensive industrial sector energy efficiency policy in China under changing market conditions. After estimating the energy-efficiency potential in energy-intensive industries such as iron & steel, copper, aluminum, cement, ammonia and petroleum refining, associated with assessment of technical and management capability, benefits on pollution abatement, water saving, implications vis-à-vis WTO competition, and other issues for each sector, two steel plants in Shandong Province were selected for pilot. Through the pilot project, the following targets would be reached:

- Developing a methodology for assessment of enterprise energy-efficiency potential
- Development of a methodology for target setting
- Development of supporting government policies
- Development of an energy conservation plan
- Development of monitoring and evaluation activities

The following incentive and supporting policies were considered two pilot plants:

- Public recognition: title of “VA Pilot Enterprise” will be conferred to the enterprises that participate in the Energy Conservation VA Pilot Project;
- Preferential treatment on the national bonds discount projects, resource conservation projects, and one outstanding and two high comprehensive utilization projects;
- Pilot enterprises allowed applying for an income tax exemption on the energy conservation resulting from projects undertaken as part of this Energy Conservation Voluntary Agreement Pilot Project;
- Pilot enterprises can apply to the SETC and MOST for listing in the project of science & technology innovation or science & technology three funds, in order to seek funds for science & technology research, development, and implementation;

- The pilot enterprises will be given primary consideration in international cooperation projects.

Voluntary agreements between Shandong Economic and Trade Commission and Laigang and Jigang were signed on April 24, 2003. The agreements set up general energy saving targets for these two steel plants. Laigang would reduce energy consumption per tonne of steel output 1.5% per year from 2000 to 2005 and Jigang would reduce 2.0% during the same period. Other specific technical criteria set for evaluation included emission reduction of SO_2 (ton), emission reduction of CO_2 (ton), energy consumed in coking (kgce/t), energy consumed in sintering (kgce/t), energy consumed in iron smelting (kgce/t), energy consumed in BOF(kgce/t), recovered volume of BOF coal gas (m3/ton) and diffusion rate of blast furnace coal gas (%). The two pilot plants are also required to report their water efficiency improvements.

An interim evaluation was conducted by domestic experts in 2005. The conclusions from the evaluation are quite promising. Both steel mills met their interim targets in terms of energy savings, CO_2 emissions reductions, and SO_2 emissions reductions. They implemented strong energy management programs and established monitoring and reporting protocols. The local governmental authority has provided assistance to enterprises in obtaining loans for energy-efficient technologies, including providing the loan guarantee, and services of government-backed technical experts free of charge to the enterprises. The annual emissions measurements which enterprises pay for are waived due to VA reporting.

Another evaluation was conducted by international experts based of the evaluation report prepared by domestic experts. Although the international experts agreed with the domestic evaluation team, they made several suggestions to address the common issues that most Chinese policies faced:

1. Independent evaluation: International experts would like to participate in plant visits and have more access to the plant management in order to make their own assessment of the project progress, not evaluate based on the evaluation report provided by others.
2. Common measures: China has its own measures for energy efficiency most of cases and makes it difficult to compare with other internationally current measures.
3. Absolute saving targets: it could be helpful to express the energy use and savings in absolute terms. This allows an easy check on the claimed energy savings and makes aggregation possible.

The pilot projects received positive attentions from media as television, newspapers, magazines, journals. Government and industry learned how new policy mechanism works. The central government intended to enlarge VAs in the top 1000 large energy consuming enterprises in the future. Additional supporting policies are under consideration.

If VAs is implemented national wide, government should consider who will pay the cost of monitoring and evaluating the policy implementation. Up to now, only tow plants conducted VAs, the cost for monitoring and evaluating is limited and can be supported by foundations. If 1000 plants conduct VAs, the evaluation cost would be high. Government should consider allocating a budget to this aim to maximize lessons learned from this policy endeavor.

6.2 Energy Tax

Energy tax or differentiated tax rate is used in many countries to increase the production costs of industries so as to spur enterprises to improve energy efficiency by upgrading their processes and adopting amore advanced technologies. Up to now, only petroleum tax is considered to limit the rapid growing on oil demand in China. This tax mainly focuses on road transportation. Every automobile owner pays a fixed annual fee based on type of his automobile and no matter how long you drive yearly. The petroleum tax will convert this fee into the oil price. If you drive more, you had to pay more.

Although the petroleum tax policy was been made for years, its implementation was postponed several times because oil price has went up a lot since then. Government didn't want put additional charges with higher oil price that could be a reason for social unstable. If the petroleum tax implemented, the direct impact would be increasing the transport cost of industry.

There is no time schedule for making other sort energy tax. But the central government started a new round of energy pricing reform at the end of 2005. It mainly set up linkage between coal price and power price. In the past ten years, coal price is decided by the market situation excluding coal listed in national plan for power generation. Power plants get two parts coal. One part is called planned coal with low price regulated by governmental authority. Another part is called non-planned coal with market price. As the energy pricing reform, the central government decided to implement full market pricing to all coal. On one hand, the coal industry increased coal price for power plants, On the other hand, electricity tariff is still controlled by the government and keep no changes. Power plants refused the price proposed by coal mines. The conflicts between coal industry and power industry have lasted for three years. In order to deal with this issue, government decided to adjust power tariff based on the changes in coal price[18].

China energy pricing is still in the transition stage from planned oriented to market oriented. There are many factors that would make energy price keep growing which will benefit to energy efficiency improvement. Energy tax is under consideration by NDRC and Ministry of Finance. How it looks like and what contents included is still confidential.

[18] NDRC official document Dec. 27 2004

6.3 Energy management information system

The central government planned to rebuild energy consumption data submitting system in 2006. About 1000 enterprises from energy intensive industrial sectors are requested to submit their energy consumption data to central government directly. These enterprises consume at least 180,000 tce or 126,000 toe of energy annually each. This could be implemented with VAs together.

Summary of this section: China intends to adopt alternative policy tools which are effective in other countries. For efficient implementation of alternative policy tools, there are many works to do.

7. Conclusions

Industry plays a very important role in China. It contributed 45.9% of GDP, consumed 70% of energy, and emitted 60.9% of CO_2 in 2004. The industrial fabric changed tremendously since China opened to the rest of the world. The share of gross output from state-owned and state-holding enterprises decreased from almost 100% to 32.3% in 2004 and meanwhile, the share of private enterprise reached 16.5% in 2004. Foreign funded enterprises and enterprises funded by Hong Kong, Macao and Taiwan contributed near one third of GDP.

Energy-intensive industrial sectors developed very fast during the 10th Five Year Plan (2001-2005). The energy intensities for main energy intensive products have decreased a lot but remain higher than the world's best practice. Efforts to enlarge equipment scales, the phasing-out of obsolete production processes, and improvement in management practice are necessary conditions to improve energy efficiency in industry.

In industry's total CO_2 emissions (2 290 Mt-CO2), near half came from fuel combustion; another 1 166 Mt-CO_2 were emitted as a result of industry's electricity consumption.

Energy efficiency policy in China experienced changes from a centrally-planned to a market-oriented economy. Energy efficiency improvements are driven by many factors – although greenhouse gas emission reductions are largely omitted. The central government has decided to take advantage of market forces to promote energy efficiency improvements.

China has a series of policies for energy efficiency improvement. Some policies are legal documents, and some belong to administrative regulations. Great attention is given to industry sectors, especially to energy-intensive sectors and large energy consuming enterprises. Most policies are based on clear principles, but lack

implementation details. Even policies with fairly detailed elements such as lists of technologies supported or prohibited by the government are taken as guidelines or directions rather than requiring compliance.

Most policies are qualitative rather than quantitive. It is difficult to evaluate the effectiveness of the various policies. Financial support to energy efficiency improvement is one part of many policies. However, there is usually no indication of actual budget in support for energy efficiency in that context. The policy and its funding are usually handled separately.

Since China has no commitment to lower its GHG emissions, no policy takes GHG emission reduction as a target. Although it is fairly clear how much energy would be saved through energy efficiency improvement by the targeted year, no CO2 emission reduction is estimated in official documents. CO2 emission reductions are a mere by-product of these policies.

If China achieved its energy conservation target that energy consumption per 10,000 yuan GDP will drop to 1.54 tonnes of coal equivalent in 2020 from 2.68 tce in 2002, China will have avoided 3.4 Gt-CO2 from 2003 to 2020.

China intends to adopt policy tools that have proven effective in other countries. Much effort will be needed to ensure the effectiveness of new approaches.

8. Reference

Anhui Ningguo Cement Plant (2002): The report on power generation by waste heat of the kiln in Ningguo Cements Plant. Website: http://green.cei.gov.cn/doc/LY31/200204192475.htm (in Chinese).

AIT – Asian Institute of Technology (1997). Technology, energy efficiency and environmental externalities in the cement industry. ISBN 974-8256-70-7

BYD – Beijing Youth Daily (2005). National economic consensus result. Dec. 21 2005 (in Chinese)

CBMIA -- China Building Materials Industry Association (2005). China Building Material Industry Yearbook 2004-2005

CCN – China Cement Network (2005). China Cement No.3 2005 Page 42 (in Chinese)

CCPC – Central Commission of the Communist Party of China (2005). Document of 5th Plenary Meeting, Sixteenth National Congress of the Communist Party of China ISNB 7-01-005204-2 (in Chinese)

CNCIC – China National Chemical Information Center (2004). China Chemical Industry Yearbook 2004 Statistics Report Fascicule

CSIA – China Steel Industrial Association (2004). China Iron and Steel Industry Statistics 2004 (in Chinese)

Cui Yuansheng (2005) China's Cement Industry – Situation, Challenge and Countermeasures. Sino-US Workshop on Environmental Management and Technologies in Cement Industry. Sept. 2005 Beijing

Di Dongren (2005) Structure of China's Cement Industry. Sino-US Workshop on Environmental Management and Technologies in Cement Industry. Sept. 2005 Beijing

EF – Energy Foundation (2004). China Energy Intensive Industrial Structure Adjustment Strategy and Relevant Policy Studies. Funded project report. June 2004

GDF -- Guangdong Development Fund (2005): The research report on cement industry, 2004 http://fund.163.com

IEA – International Energy Agency (2005). Key World Energy Statistics 2005. Page 48

IEEJ – The Institute of Energy Economics Japan (2005). Handbook of Energy & Economic Statistics in Japan 2005. Page247

Le Jingping (2005). Challenges for Provincial Government for Project Implementation. www.efchina.org

Lei Qianzhi (2005). The golden period of structure adjustment of cement industry. China Building Material Industry Yearbook 2004-2005 (in Chinese)

Liu Zhiping (2004): The trend of energy efficiency of China in 2002 (in Chinese). www.eri.org.cn

NBS – National Bureau of Statistics of China (2005a). China Statistical Yearbook 2005.

NBS – National Bureau of Statistics of China (2005b). China Energy Statistical Yearbook 2004

NBS – National Bureau of Statistics of China (2000). China Statistical Yearbook 2000.

NDRC – National Development and Reform Commission (2005a). Building an Efficient Society Exhibition 2005.

NRDC – National Development and Reform Commission (2005b): China Medium and Long Term Energy Conservation Plan. China Environmental Science Press. ISBN 7-80209-035-0

Pan Jiong (----): The technique and application of power generation by waste heat in moderate and low temperature in cement plant (in Chinese). www.chinacement.org

Price, Lynn et al (2005). Development of CDM Methodologies for Energy Conservation Projects. Presented at COP 11 Side Event, Dec. 2005

QZWB – Quanzhou Evening Paper (2005). News of July 21st 2005 (in Chinese)

SETC – State Economy and Trade Commission (2004). Governmental Management on Energy Efficiency. ISBN 7-5083-2006-9，2004 (in Chinese)

SINOPEC (2005). China Petrochemical Corporation Yearbook 2005. Page 84

Wang Jialin (2005) 32 cooling storage projects in Beijing. www.wzzb.com

Wang Qingyi (2005) Energy Data 2005. Coal Economic Research 2005 Special Issue

Zhao Jiarong (2005) Preliminary ideas on amending the energy conservation law. www.efchina

Annex I Clarification of industrial sectors (national standard)

Mining and quarrying includes

Mining and Washing of Coal
Extraction of Petroleum and Natural Gas
Mining and Processing of Ferrous Metal Ores
Mining and Processing of Non-Ferrous Metal Ores
Mining and Processing of Nonmetal Ores
Mining of Other Ores

Manufacturing includes

Processing of Food from Agricultural Products
Manufacture of Foods
Manufacture of Beverages
Manufacture of Tobacco
Manufacture of Textile
Manufacture of Textile Wearing Apparel, Footwear, and Caps
Manufacture of Leather, Fur, Feather and Related Products
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products
Manufacture of Furniture
Manufacture of Paper and Paper Products
Printing, Reproduction of Recording Media
Manufacture of Articles for Culture, Education and Sport Activity
Processing of Petroleum, Coking, Processing of Nuclear Fuel
Manufacture of Raw Chemical Materials and Chemical Products
Manufacture of Medicines
Manufacture of Chemical Fibers
Manufacture of Rubber
Manufacture of Plastics
Manufacture of Non-metallic Mineral Products
Smelting and Pressing of Ferrous Metals
Smelting and Pressing of Non-ferrous Metals
Manufacture of Metal Products
Manufacture of General Purpose Machinery
Manufacture of Special Purpose Machinery

Manufacture of Transport Equipment

Manufacture of Electrical Machinery and Equipment

Manufacture of Communication Equipment, Computers and Other Electronic Equipment

Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work

Manufacture of Artwork and Other Manufacturing

Recycling and Disposal of Waste

Electric Power, Gas and Water Production and Supply includes

Production and Distribution of Electric Power and Heat Power

Production and Distribution of Gas

Production and Distribution of Water

Annex II 10 implementation measures for guaranteeing the energy saving target (NDRC 2005b)

1. Adhere to and implement the guideline of giving priority to energy conservation: Priority of energy conservation should be reflected in formulating and practicing development strategies and plans, industrial policies and policies related to investment management, finance, taxation, banking and pricing.
2. Formulate and implement unified and harmonized energy and environment policies to promote energy conservation: coal should be used primarily in power generation. Petroleum should be used primarily in transportation, in the chemical industry and other fields where alternative fuels are not readily available. To better use advanced energy efficient and environmental friendly boilers to reduce pollution emission from coal burning.
3. Formulate and implement industrial policies to facilitate structure adjustment: To formulate policy measures of promoting development of low energy-intensive, high value-added and labor-intensive tertiary industry. The government will implement the system of eliminating backward and energy intensive products and equipment. Energy conservation management authorities will regularly publicize lists of energy intensive products and equipment that should be eliminated for use.
4. Formulate and implement incentive policies to intensify energy conservation: Issuing the catalogue of energy-saving equipment and products and implementing incentive policies for producing or using the products in the list. Government will provide funding and subsidy or deducted loan to support some major energy-saving projects and major technology development and demonstration project. Expenses necessary for applications such as government energy conservation management and government agencies energy conservation renovation should be included into corresponding public budgets.
5. Strengthen energy conservation management: To make a series of management methods on energy conservation; establish and perfect the energy conservation monitoring mechanism, supervise and inspect energy consumption and energy

conservation management of energy intensive industrial sectors.

6. Accelerate development, demonstration and promotion of energy conservation technology: China's authorities will formulate plans on developing, demonstrating and promoting energy saving technology to identify milestone, priority policies supporting energy saving and implement them step by step. More research projects on energy efficient will be listed in national scientific and technological plans and the government will provide financial support for these projects with high-input and high-risk.
7. Promote new market-based energy conservation mechanism including energy conservation information release system, IRP/DSM, energy-saving products certification and energy efficiency labeling, EMC (or ESCOs), energy conservation investment guarantee and energy conservation voluntary agreements.
8. Reinforce energy conservation regulation on key energy consuming enterprises: Supervise and inspect energy utilization to those enterprises that consume energy over 10,000 tce annually. The government will publish a list of these enterprises describing their level of energy use and comparing their performance with those of more advanced counterparts at home and abroad.
9. Intensify promotion, education and training of energy conservation: Incorporate the energy conservation into the education system and technical training. Launch a national energy conservation promotion week in power demand peak season every year.
10. Enhance organization and leadership, and promote program implementation.

Annex III Contents of the Policy Outlines for Energy Conservation Technologies 2005 edition and 1996 edition comparison

2005 edition[19]	1996 edition[20]
Chapter 1 Optimizing allocation and reasonable utilization of energy resources	Chapter 1 Optimizing allocation and reasonable utilization of energy resources
Chapter 2 Speed up technical innovation, retrofit equipment, recover and reuse of waste heat, energy and combustible gases	Chapter 2 Speed up upgrade of industrial kilns, boilers and other energy-consuming equipment Chapter 3 Increase heat supply efficiency Chapter 4 Waste heat and energy utilization for industrial kilns Chapter 5 Recovery of combustible gases from industrial production processes
Chapter 3 Development and popularization of energy efficient new material	Chapter 7 Development and popularization of energy efficient new material

[19] www.sndrc.gov.cn

[20] www.emfuel.com/data/inform.htm

Chapter 4 **Implement strictly energy efficient standards, norms**. Enhance measuring, controlling and auditing at energy utilization, and energy management	Chapter 8 Enhance measuring, controlling and auditing at energy utilization, and energy management
Chapter 5 Industrial energy efficiency 5.1 Power industry **1.1** Iron and steel industry **1.2** Nonferrous metals **1.3** Building materials **1.4** Chemical industry **1.5** Coal industry **1.6** Oil and natural gas **1.7** Petroleum chemical **1.8** Machinery and electric equipment **1.9** Information technology industry **1.10** Light industry **1.11** Textile industry	Chapter 12 Process energy efficiency improvement in energy-intensive industries 12.1 Power industry 12.2 Iron and steel industry 12.3 Nonferrous metals 12.4 Cement 12.5 Chemical industry 12.6 Coal industry 12.7 Oil and natural gas 12.8 Petroleum Chemical 12.9 Machinery and electric equipment 12.10 Light industry 12.11 Textile industry
Chapter 6 Efficient buildings 6.1 Efficient public buildings 6.2 Efficient residential buildings 6.3 Energy conservation for cities and utilities	Chapter 10 Paying attentions at energy efficient buildings Chapter 11 Enhance management of residential energy utilization
Chapter 7 Energy efficiency for transportation 7.1 Railways 7.2 Road and waterways 7.3 Efficient automobiles	Chapter 9 Build an energy efficient, integrated transportation system
Chapter 8 Energy efficiency for agriculture 8.1 Rural energy system construction and conservation 8.2 Energy utilization for agricultural production	12.12 Energy consumption for agriculture
Chapter 9 Energy conservation for governmental agencies	
	Chapter 6 New energy and energy substitution technologies