Corporate Environmental Management in China: An Overview

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1. Country Profile

The People's Republic of China is situated in eastern Asia, bounded by the Pacific in the east. As the third largest country in the world, next to Canada and Russia, it has a total area of 9.6 million square kilometers, or one-fifteenth of the world's landmass. China's administrative units are currently based on a four-level system dividing the nation into provinces, prefecture-level cities, counties or county level cities, and townships. At provincial level, China is divided into 23 provinces, 5 autonomous regions, 4 metropolises directly under the Central Government, and 2 special administrative regions (Hong Kong and Macao).

1.1 Population growth and urbanization

Chinese population, the largest in the world, has doubled over the past 50 years. As indicated in Fig.1, total population exceeded 1.3 billion in 2005, which accounted for around one-fifth of the world's total. The population growth appeared a downward trend since the introduction of Birth Control Policy in the end of 1970's. Yearly rate of growth rate of population dropped below 1% in 1998 and kept decreasing to 0.6% by 2005 *(NBSC, 2006)*.

Along with the rapid urbanization in the last two decades, people living in urban areas reached 562 million by the end of 2005, up 7% from five years ago. Urban population shares 43% of the total recently. As huge base of population and fast urbanization, agriculture, energy supplies, urban infrastructure, and housing all have come under increasing stress in China.

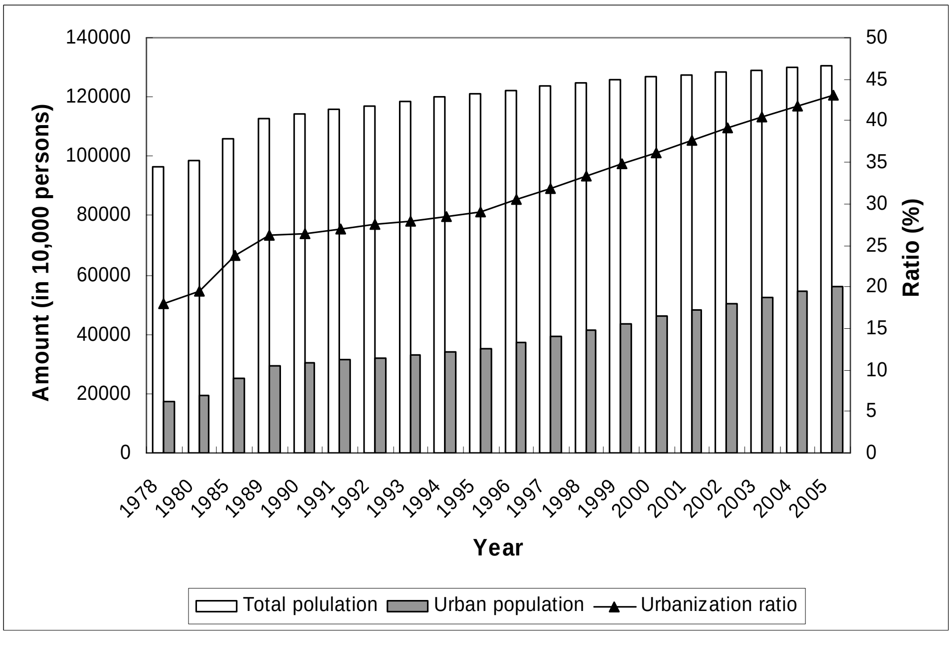

Fig.1: Population growth and urbanization in China (1978-2005)

1.2 Economic growth

Since China initiated the economic reforms in 1978, GDP (Gross Domestic Product), in total and per capita average, has increased dramatically. Chinese GDP kept growing with a yearly ratio of around 10% particularly in the past 15 years, and reached 18308.48 billion CNY (Chinese currency unit, 1USD ≈ 7.6 CNY currently) in 2005 (see Fig.2) *(NBSC, 2006)*. However, the per capita GDP of China is still quite low. It ranks the 110th in a world list which covers 180 countries or regions in total. The economic development is the highest priority for China in the medium and even long run in order to eradicate poverty and alleviate other social pressures such as environmental pollution, etc.

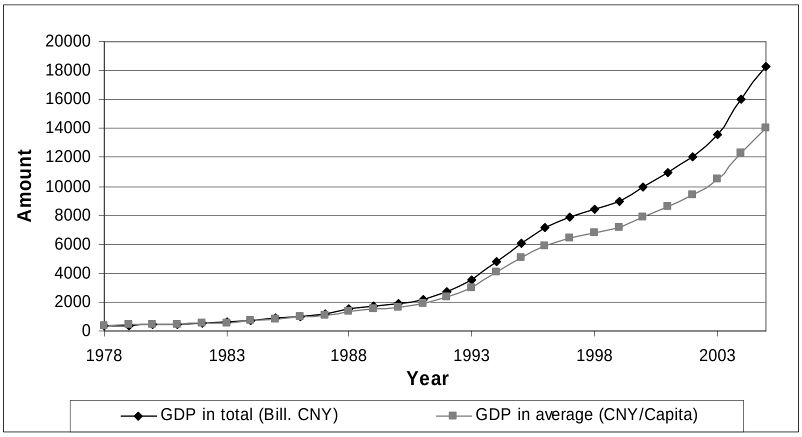

Fig.2: GDP growth in China (1978-2005)

One problem for Chinese economic development is the geographically uneven growth. Fig.3 expressed the GDP relevant data of the 4 defined macro regions of China in 2005 in the forms of total and per capita average *(NBSC, 2006)*. Big gap obviously existed between the most developed coastal eastern regions and the broad but relatively undeveloped western provinces. GDP per capita of eastern region was 2.5 times higher than that of western. Aiming to balance the national wide development, a series of national-level strategies, e.g. western development, prospering traditional industrial bases in northeast and promoting economic rise in central, have been initiated to speed up the social and economic growth in the backward regions.

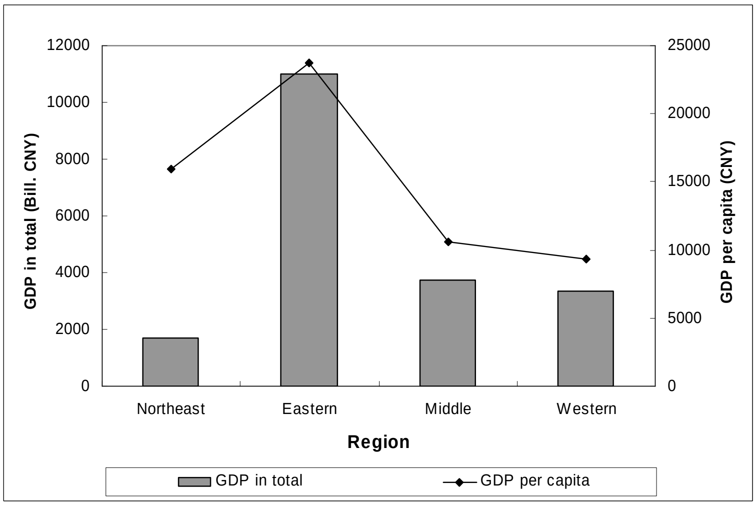

Fig.3: GDP of different regions in China (in 2005)

1.3 Industrial portfolio

Industrial sectors are categorized into primary agriculture, secondary manufacturing and construction, and tertiary services in China. Chinese industrial structure changed significantly during 1990's. Fig.4 indicated the fluctuation of the shares in total GDP of the three sectors during 1978-2005 *(NBSC, 2006)*. Agricultural contributions accounted for nearly 25% of total economy in 1990. This ratio decreased to 12.6% by 2005. Accordingly, the ratio of tertiary industry increased from 30% to 40% in the same period. Manufacturing and construction is sharing about half of the total GDP.

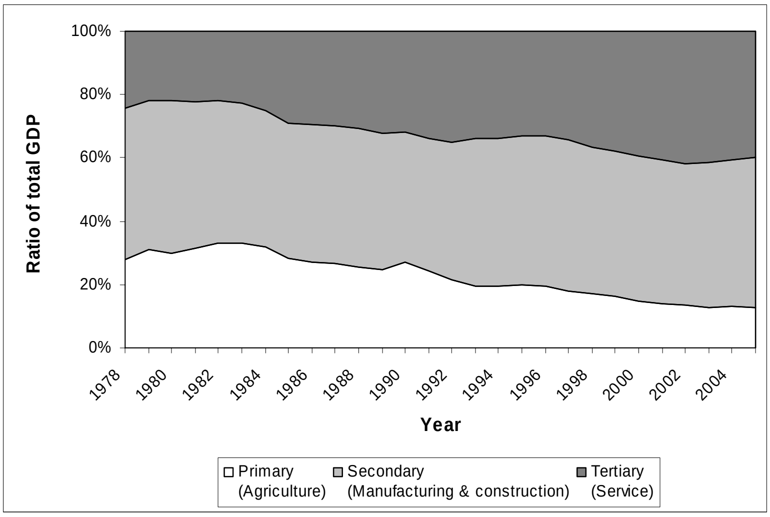

Fig. 4: Sector contribution to GDP in China (1978-2005)

1.3.1 Classification of manufacturing industry by scale

The number of state-owned and non-state-owned industrial enterprises above designated size (Yearly sales are over 5 million CNY) was 271,835 in 2005. Within which, 89% was categorized as small sized [1]. Ten percent had medium scale. The large enterprises shared 1% of the total (see Fig.5).

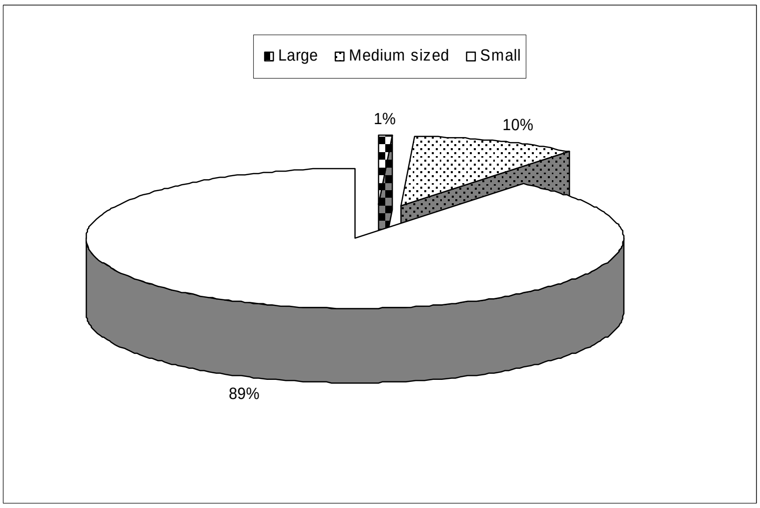

Fig.5: Number ratio of industrial enterprises by their scales (in 2005)

---- [1] The large enterprises refer to those which have 2,000 or more staffs, 300 million CNY or more annual sales and 400 million CNY or more total capitals. The small enterprises refer to those which have less than 300 staffs, or less than 30 million CNY annual sales or less than 40 million CNY total capitals. The others are classified as medium sized *(NBSC, 2003)*.

1.3.2 Classification of manufacturing industry by ownership

Fig.6 shows the ratio of enterprises by their ownerships in 2005. About 10% was state owned or state holding. Twenty one percent was funded by the investments from Hongkong, Macao, Taiwan and foreign countries. Most of them (69%) were characterized as private, joint ownership or share holdings, etc. Based on Fig.7, large enterprises possessed 39% of the total capital of all manufacturers. The capital share of medium sized enterprises was 34%. The rest 27% capital was operated by small enterprises *(NBSC, 2006)*.

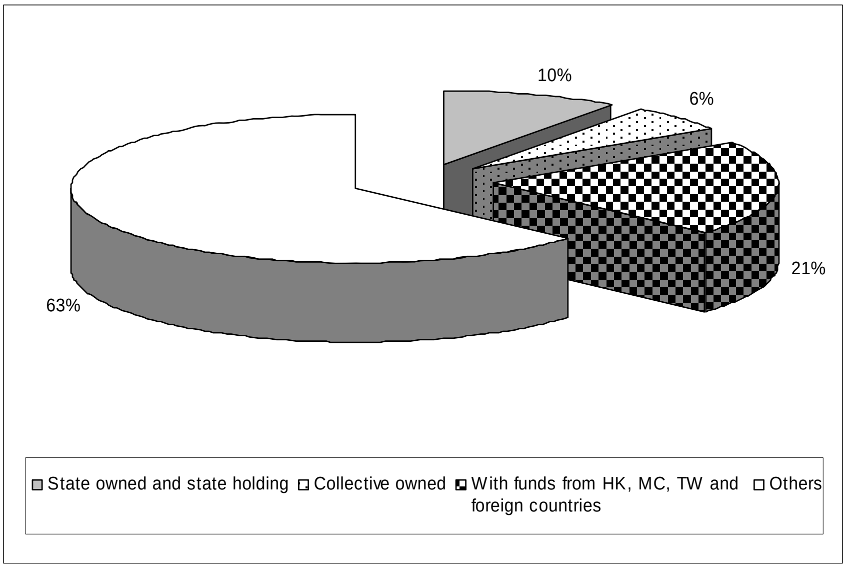

Fig.6: Number ratio of industrial enterprises by their ownerships (in 2005)

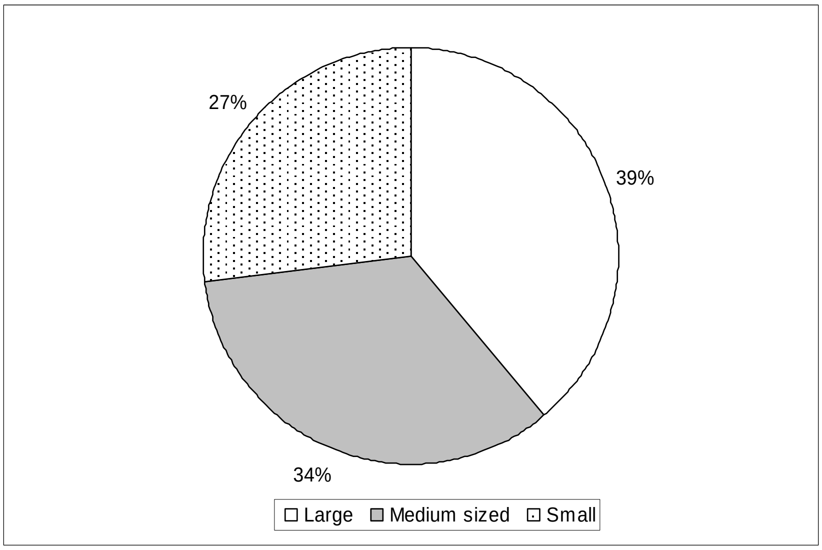

Fig.7: Capital share of industrial enterprises by their scales (in 2005)

1.3.3 Key manufacturing sectors by employment

Fig.8 showed the selected industrial sectors which had more than 1 million of employees in 2005 *(NBSC, 2006)*. About 2.716 million persons were hired by the textile manufacturers. The next sectors included transport equipment, information technology & product, electricity and heat generation & supply, chemical product manufacturing, non-metallic mineral product, and ferrous metals processing, etc. These sectors are playing greater roles in providing employment opportunities.

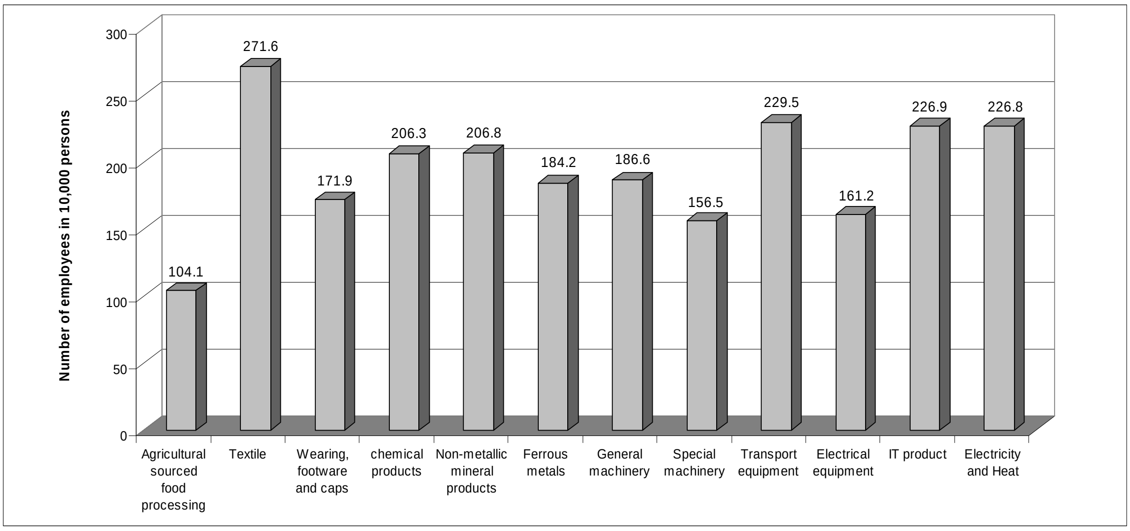

Fig.8: Number of employees in selected industrial sectors (in 2005)

2. Environmental Problems and Development Challenges

2.1 High energy consumption to sustain the economic growth

Fig.9 indicated the energy consumption in total and in average per unit of GDP during 1990-2005 in China *(NBSC, 2006)*. It is encouraging that total energy consumption only doubled for nearly 10 times of GDP growth. Average energy consumption decreased from 5.29 to 1.49 tons of SCE per 10,000 CNY GDP in 1990's (SCE: Standard Coal Equivalent). It rebounded slightly in recent years.

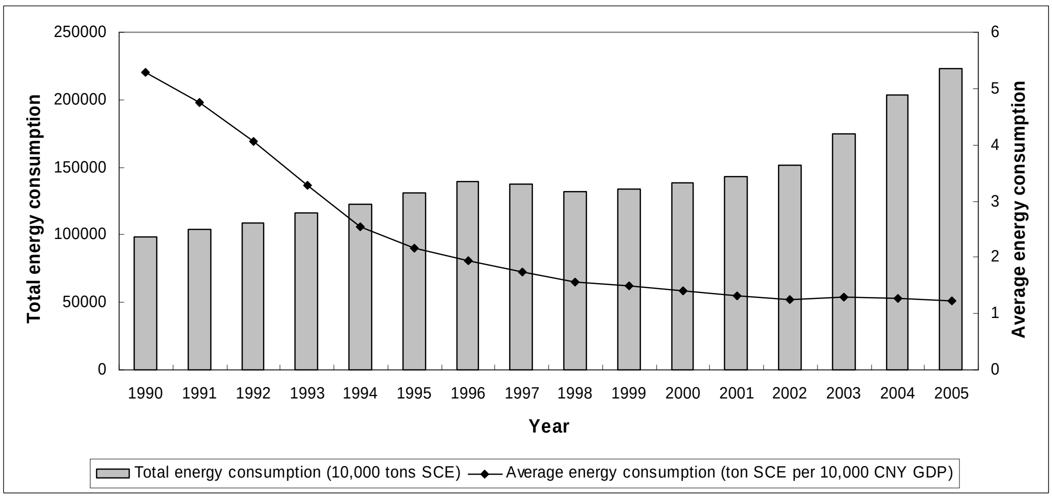

Fig.9: Energy consumption in China (1990-2005)

Amongst all the social activities, manufacturing industry shared 71% of the total energy consumption in 2005 (see Fig.10). The non-production consumption activities used 10% of the total energy. The ratios for agriculture and construction are 4% and 2% respectively. The rest 13% was consumed by other social service activities *(NBSC, 2006)*. Fig.11 showed the share of different sourced energy during 1978-2005. Coal is the dominant source of energy supply even though its share appeared a slightly decreasing trend (from 75% in 1995 to 68.9% in 2005). Accordingly, the ratios of oil and renewable energy such as hydro and wind power have been increasing in the last decade. The coal dominated energy supply structure in China is very unique in the world if comparing with other countries (see Fig.12). Coal shared nearly 70% of the total energy consumed in China, while this ratio in developed countries is typically 5-25%.

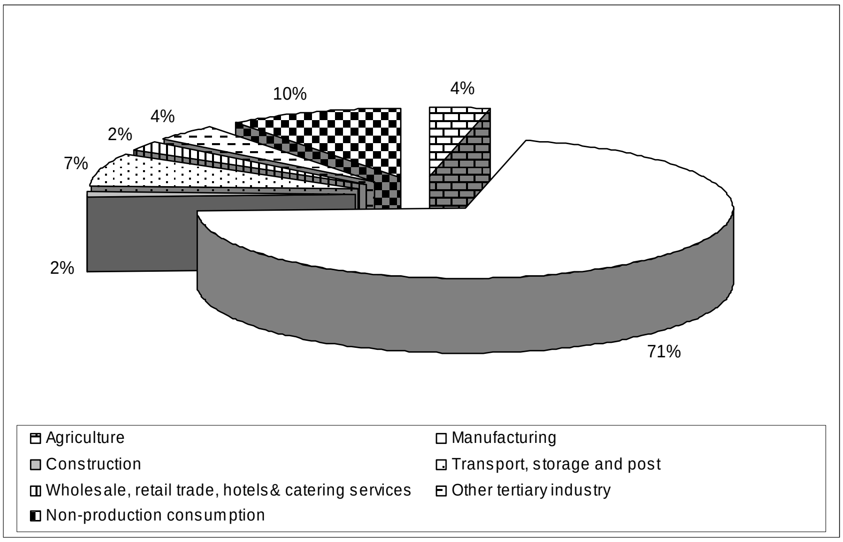

Fig.10: Ratio of energy consumption by sectors (in 2005)

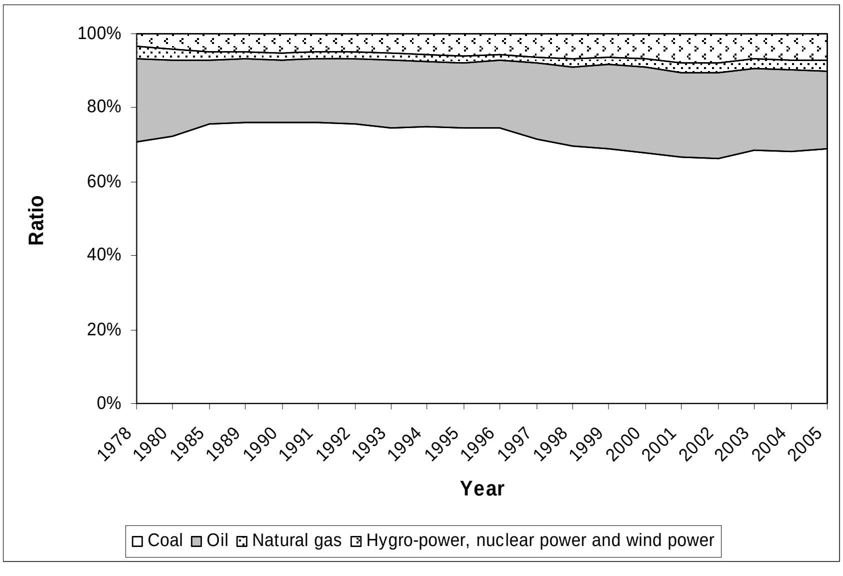

Fig.11: Ratio of the consumed energy by sources (1978-2005)

As illustrated in Fig.13, average energy consumption in China was 13.56 tons of SCE per 10,000 USD of GDP in 2006, which was more than 8 times of that of Japan and was about 5 times of that of USA. It was also much higher than some other large developing countries like India and Brazil. The low energy efficiency in China could be partially attributed to the irrational structure of the energy sources. Lack of clean manufacturing technologies may be another essential reason to explain the high energy intensity of and heavy pollutant load from industries. This has limited the quality and sustainability of economic growth in China. Improving the energy efficiency in China is crucial for energy conservation and emission mitigation in the near future.

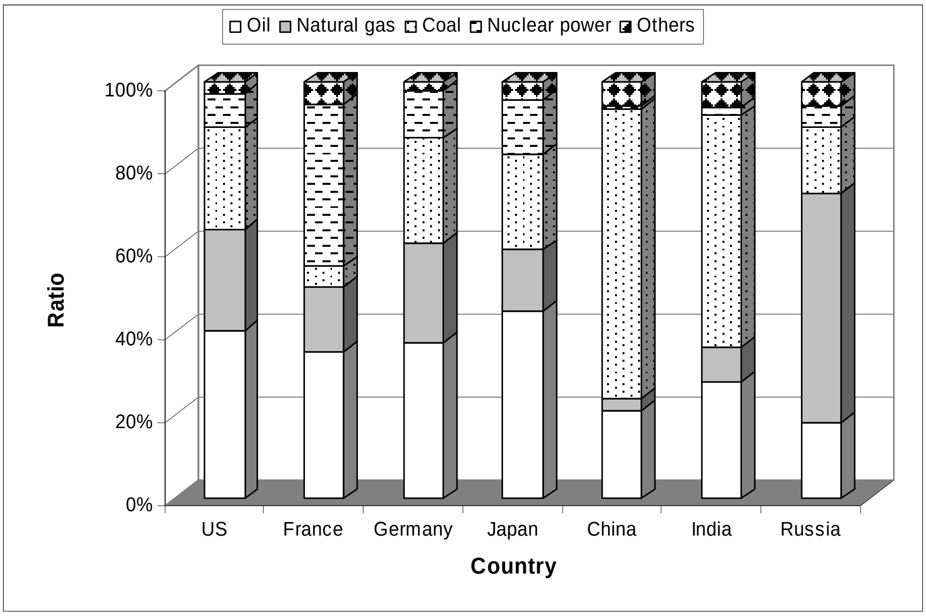

Fig.12: Composition of energy sources in selected countries (in 2006)

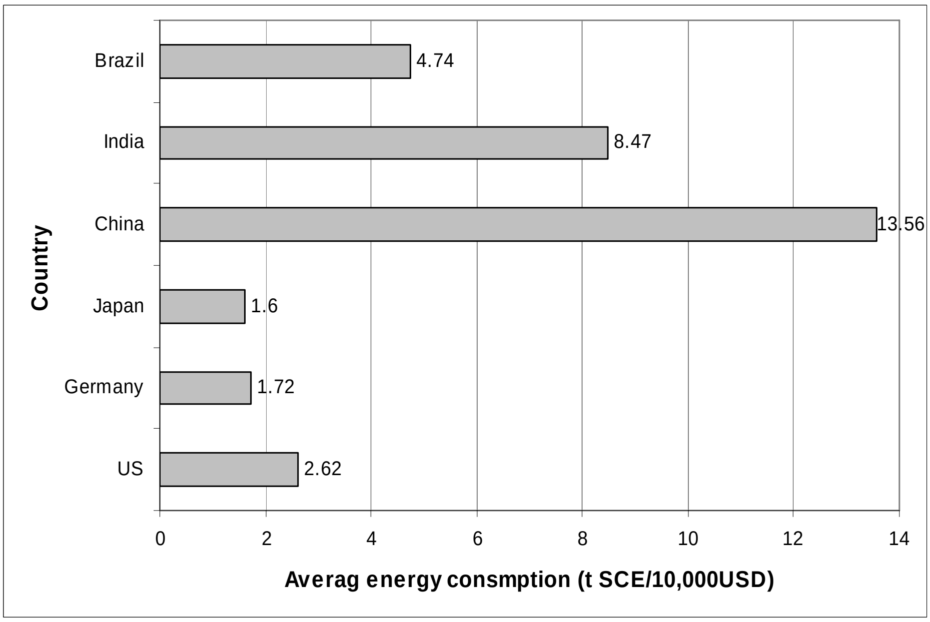

Fig.13: Energy consumption averaged by GDP in selected countries (in 2006)

There is big gap of energy efficiency in different regions of China (see Fig.14) *(NBSC, 2006)*. The relative developed provinces in economy such as Beijing, Tianjin, eastern coastal Shanghai, Jiangsu, zhejiang and southern Guangdong provinces have much higher energy efficiency than the western Shanxi, Inner Mongolia, Guizhou and Ningxia provinces. The energy efficiency of the provinces in central China is somewhere in the between.

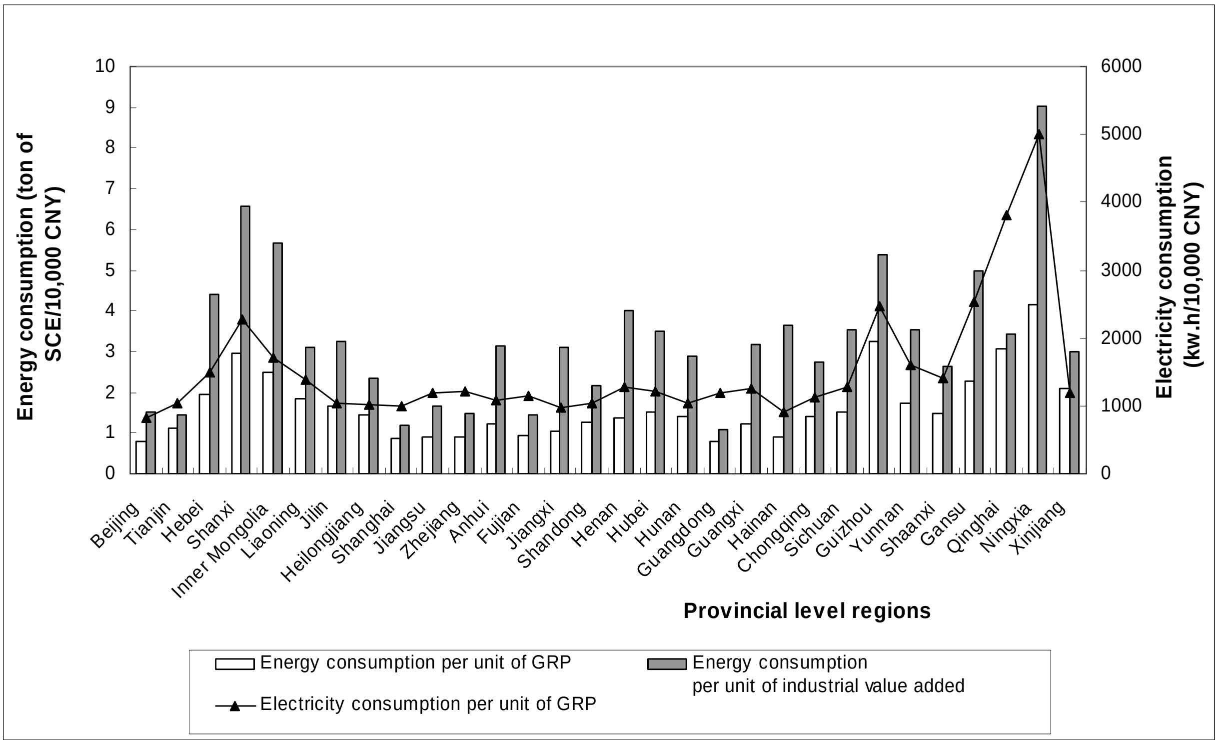

Fig.14: Energy efficiency in different provinces of China (in 2005)

2.2 Intensity of environmental pollution

Undoubtedly, environmental pollution and resource degradation are severe in China. They negatively impact human health and quality of life, as well as economic and social development *(Economy, 2004; SEPA, 2002; OECD, 2002; World Bank, 2001)*. In the last 25 years, although the advances in technology and economic efficiency, coupled with pollution control policies, have positively affected air and water pollution loads, great challenges remain in further improving environmental status in China.

2.2.1 Air pollution trends

Although levels of SO_2 and particulates have declined since the 1980's, cities in China still rank among the most polluted in the world. Suspended particulate levels are higher in northern cities, due in part to industrial activities, but also because of geographic and meteorological conditions that make these cities more vulnerable to particulate pollution than cities in the south, holding emission constant. In both northern and southern cities, particulates concentrations show a downward trend from 1980 until the early 1990's and then remain relatively flat. SO_2 and NOx concentrations also show a downward trend. Since 2003, however, NOx and particularly SO_2 concentrations have increased. When measured in terms of the number of cities violating Chinese air quality standards (cities which are classified as Grade III or worse), air quality has shown certain improvement since 1999. Fig.15 showed the ratio of cities by the categories of air quality during 1999-2005. The number of cities worse than Grade III declined steadily. Nevertheless, about 50% of China's cities still could not meet national air quality standards.

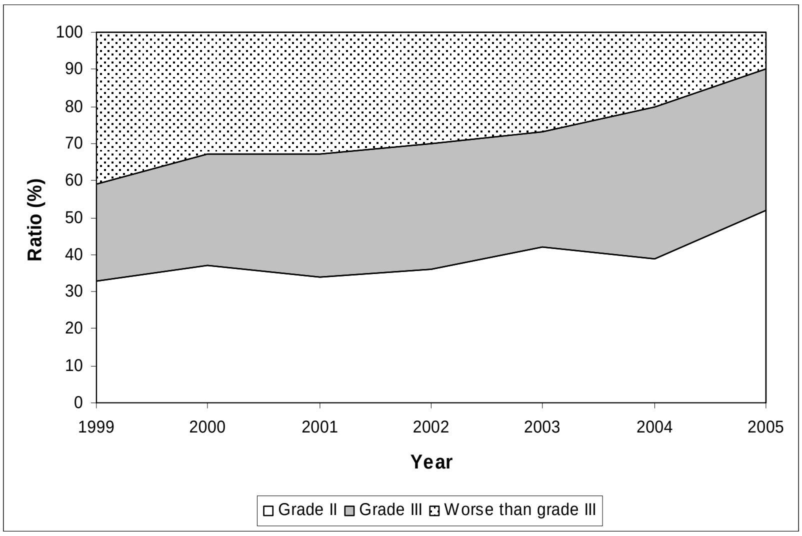

Fig.15: Ratio of cities by air quality (1999-2005)

Tab.1 presents the distribution of monitored cities by PM_{10} and SO_2 levels in 2003 and 2004. In 2003, 54% of the 341 monitored cities, sharing 58% of the urban population, reported annual PM_{10} level in excess of $100\mu g/m^3$, which is twice the US yearly average standard. Twenty one percent of cities reported annual average levels over $150\mu g/m^3$. Sulfur dioxide levels measure up better in terms of international standards. In 2003, almost three quarters of the monitored cities has SO_2 levels below the US annual average standard ($60\ \mu g/m^3$), suggesting that particulate air pollution is likely to be a more important health concern in the near future.

Tab.1: Distribution of PM10 and SO2 levels in 341 monitored cities (in 2003 and 2004)

Distribution of PM_{10} levels	% of cities		Distribution of SO_2 levels	% of cities	
	2003	2004		2003	2004
$PM_{10} \leq 100\mu g/m^3$	46	47	$SO_2 \leq 60\mu g/m^3$	74	74
$100 < PM_{10} \leq 150\mu g/m^3$	33	39	$60 < SO_2 \leq 100\mu g/m^3$	14	17
$150\mu g/m^3 < PM_{10}$	21	14	$100\mu g/m^3 < SO_2$	12	9

2.2.2 Water quality and trend of water pollution

Surface water quality in China is poor in most densely populated regions of the country, in spite of the increasing municipal wastewater treatment capacity. Water quality is monitored by State Environmental Protection Administration (SEPA) in about 500 river sections and by the Ministry of Water Resources (MWR) in more than 2000 sections across the main river basins. The surface water quality is classified into five categories based on national water standards.

Recent trend suggests that quality is worsening in the main river systems in the North, while improving in the South. In 2004, about 25,000 km of Chinese rivers failed to meet the water quality standards for aquatic life and about 90% of the sections of rivers across urban areas were seriously polluted *(MWR, 2005)*. Many of the most polluted rivers have been void of fish for many years. Among the 593 sections of the rivers monitored by National Environmental Monitoring Network in 2006, 40% met the Grade I-III surface water quality standards (water that is safe for human being use), 32% met grade IV-V standards, and 28% failed even to meet Grade V (see Fig.16). The bulk of the violations occurred in the north areas with high population density.

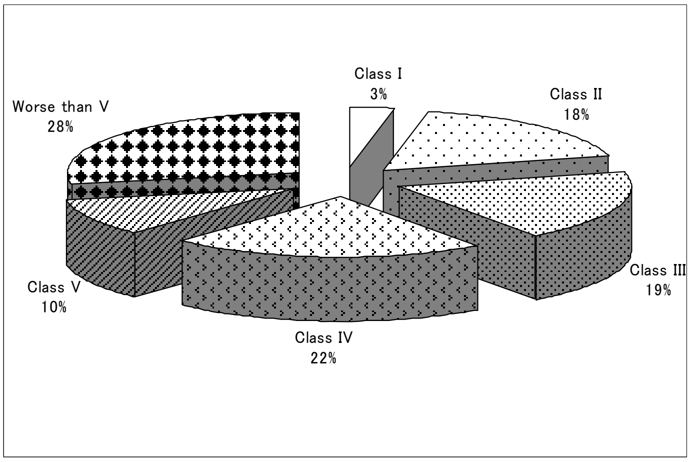

Fig.16: Surface water quality in China (in 2006)

The water quality of the seven major river basins in 2006 was indicated in Fig.17. Based on the monitoring results from 408 sections located in 197 tributaries of the seven river basins, the southern Yangtze and Pearl rivers had better water quality than the others in north. Liaohe and Haihe rivers have been heavily polluted. The main pollutants are COD, oil and NH_3-N *(SEPA, 2007a)*.

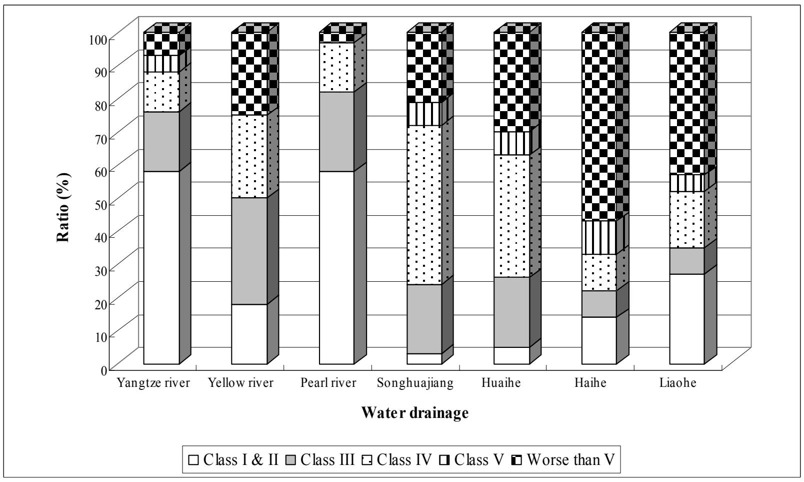

Fig.17: Water quality of 7 major water drainages in China (in 2006)

Pollution of lakes is also a serious environmental problem in China. Seventy five percent of the lakes exhibit some degree of eutrophication. Among the 27 major lakes and reservoirs monitored in

2004, none of them met the Grade I water quality standard. Most sites have lower quality levels: four are Grade IV, six are Grade V, and ten failed to meet even Grade V standard. The three lakes (Taihu, Chaohu, and Dianchi), which were selected as the key areas for water pollution control 10 years ago, were among the lakes failing to meet the Grade V standard. Total nitrogen and phosphorus were the main pollutants contributing to the poor quality of lakes *(SEPA, 2005)*.

2.2.3 Off-target performances in the 10th FYP

To illustrate, China has not been able to realize most of its 10th five-year-plan (FYP, 2001-2005) targets for air and water pollution control (see Tab.2). The most pressing off-target performance is the drastic increase of industrial-based SO_2 emission, which has reversed the downward trend in SO_2 levels and degraded air quality. Most of the coal, the main energy sources, is burned in thermal power plants or in industrial boilers, leading to high SO_2 and particulate emissions.

Tab.2: Environmental targets set for the 10th FYP vs. actual performance (in Mill. tons)

Indicators	Actual 2000	Planned 2005	Actual 2005	Comparison with planned 2005 (%)
Air pollution:				
SO_2 emissions	19.9	17.9	25.5	42
Industrial based	16.1	14.5	21.7	50
Soot emissions	11.7	10.6	11.8	11
Industrial based	9.5	8.5	9.5	12
Industrial dust emissions	10.9	8.98	9.1	1
Water pollution:				
COD discharge	14.5	13.0	14.1	8
Industrial based	7	6.7	5.5	-18
Ammonia nitrogen	1.8	1.65	1.5	-9
Industrial based	0.8	0.7	0.525	-25

Source: Estimation based on China Environmental Yearbook 2001 and 2006.

2.2.4 Cost of the pollution

A World Bank study conducted in 1995 showed that air and water pollution damage, especially the dangers that fine airborne particulates posed to human health, have been estimated to be at least USD 54 billion annually, or nearly 8% of the GDP of China *(World Bank, 1997)*. Many researchers *(Rogers et al., 1997)* also pointed out that GDP growth in China continued to reduce the opportunities of future generations to enjoy natural resources and the environmental base for meeting their needs.

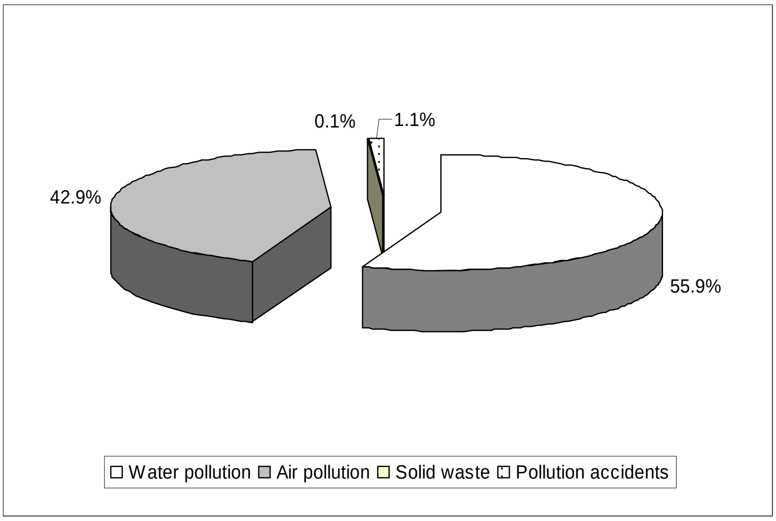

Fig.18: Ratio of the cost by factors (in 2004)

Based on another latest study co-organized by SEPA and National Bureau of Statistics *(CAEP et al., 2006)*, total cost of environmental pollution and deterioration was 511.82 billion CNY in 2004 and accounted for 3.05% of GDP in China. Pollution of water and air were the major causes for the environmental damages. 55.9% and 42.9% of the total cost came from water and air pollution respectively (see Fig.18). The cost of environmental damages by macro regions was indicated in Fig.19. The environmental deterioration cost of the 11 provincial regions in eastern was 283.13 billion CNY, which was 55.8% of the total estimation. Those in the middle and western regions were 132.17 and 91.7 billion CNY respectively. Their shares of local total GDP were 2.85%, 3.32% and 3.2%.

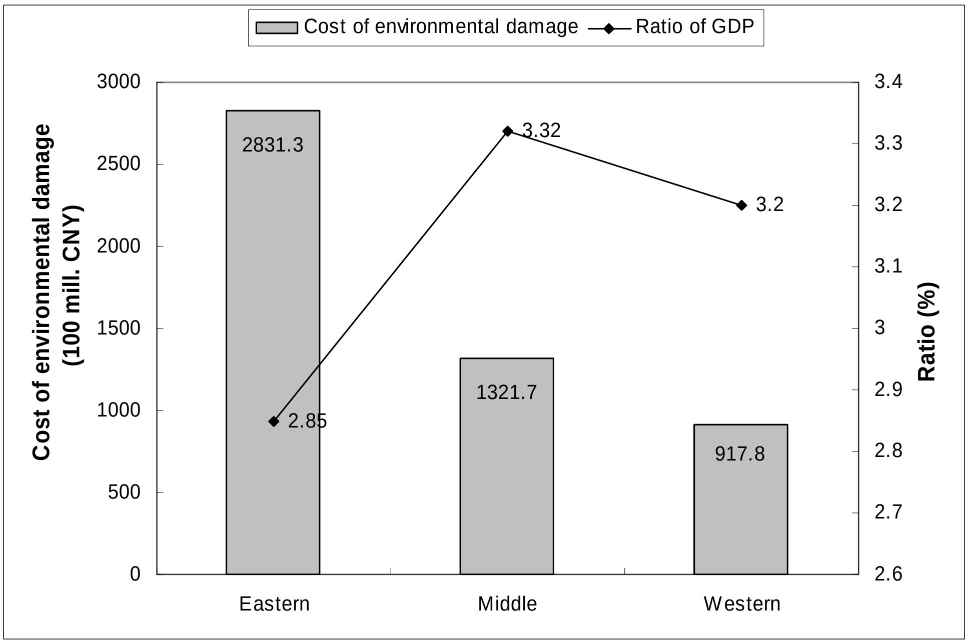

Fig.19: Cost of environmental damages by regions (in 2004)

3. Pollution Contributions of Manufacturing Industries

Manufacturing industries are the main contributors to environmental pollution in China. The industrial sourced emissions accounted for 60-70% of national total pollutant loads during the last two decades. Based on the statistics data of SEPA, over 19.4 billion tons of wastewater, 7.04 million tons of organic pollutants in term of COD (Chemical Oxygen Demand), 16.12 million tons of SO_2, 9.53 million tons of soot, 10.92 million tons of powder dust, and 31.83 million tons of industrial solid waste were released from industries in 2000 *(SEPA, 2001)*. Industrial pollution prevention and control is still the key area for the improvement of environmental quality at least in the medium term.

Fig.20 showed the shares of certain major pollutants discharged from industries in the total amount of emissions during the 10th FYP. The industrial wastewater discharge volume accounted for nearly half of the total. The shares of COD and NH_3-N slightly fluctuated around 40% and 30% respectively. More than 80% of SO_2 emission came from industrial activities, and this share appeared an increasing trend in the last 5 years.

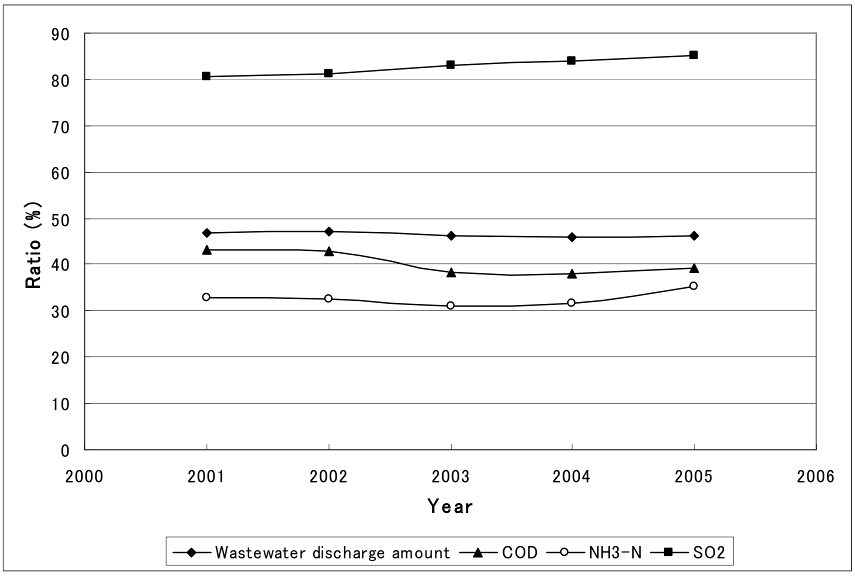

Fig.20: Contribution ratio of industries to the total emissions (2001-2005)

3.1 Water pollutants discharged from industries

Wastewater discharged from industries steadily fluctuated around 20 billion tons per year during 1996-2003 but had sudden increases in following years of 2004 and 2005 (see Fig.21). This number reached 24.31 billion tons in 2005. Due to the persistent efforts on industrial water pollution prevention and control in the past 10 years, the discharge amount of COD from industries was cut off from about 8 million tons in 1998 to 5.5 million tons in 2005. However, the discharge amount of ammonia nitrogen appeared almost constant. It is because the measures to control water pollution control in recent years are solely targeted on organic pollutants. COD and BOD (Biological Oxygen Demand) were selected as major pollutants for evaluation in national water pollution control programs.

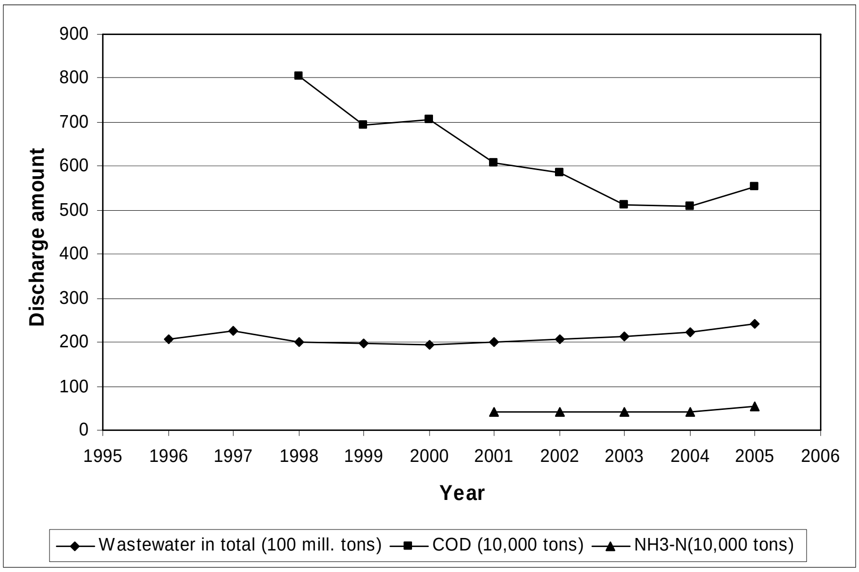

Fig.21: Water pollutants discharged from industries (1996-2005)

Moreover, the industrial sectors such as pulp and paper, food production & processing, textiles and tanning, which contribute the most to water pollution, have all retained their respective shares of the Gross Industrial Output Value (GIOV) in the process of industrialization. This implies that China has not substantially abated water pollution derived from industrial sources through adjusting the industrial structure favoring cleaner downstream production.

3.2 Air pollutant emissions from industries

Fig.22 showed the emissions of main air pollutants from industries during 1997~2005. Soot generated from fuel burning and dust from other manufacturing processes had significant decreasing curves. About 45% of soot and dust emissions had been cut off. On the contrary, industrial SO_2 emission increased by nearly 20% in the same period. Most industrial polluters hesitate to take measures to reduce of their SO_2 emissions due to the lack of national policies, high cost and non-availability of technologies. There shall be great market potential for the de-sulfurization technologies and equipments in China in near future.

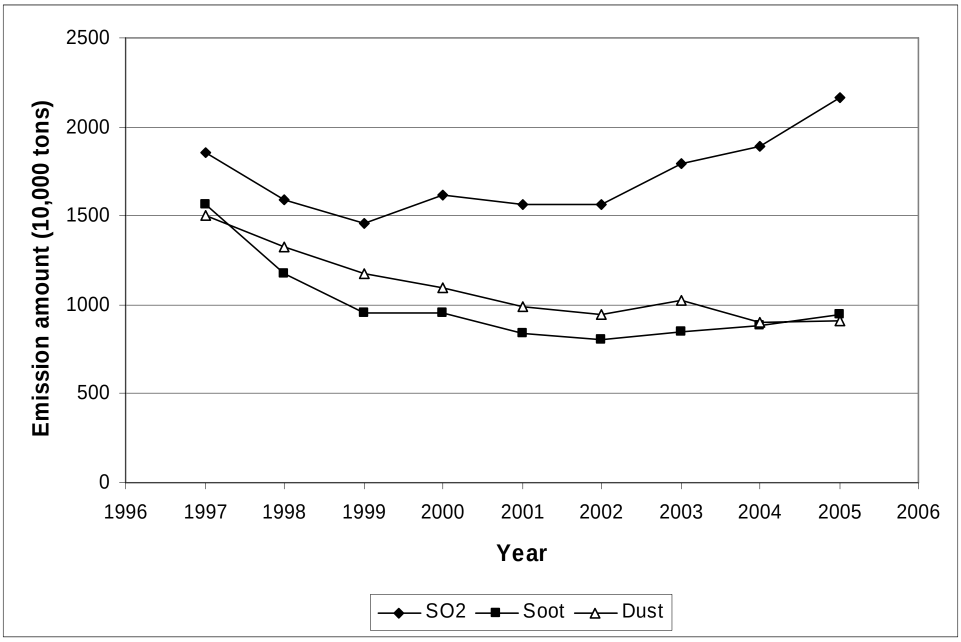

Fig.22: Air pollutant emissions from industries (1997-2005)

3.3 Industrial solid waste generation and management

Along with the economic growth, the generation amount of industrial solid wastes doubled in the last 10 years from 659 million tons to more than 1.3 billion tons (see Fig.23). During the same period, the integration utilization amount increased dramatically which made an increase of the ratio of integrated utilization of wastes from 43% to 56.1%. The generated waste to be disposed of had an obvious increase too. About 262 million tons of solid wastes from industries were left away from proper management in 2005.

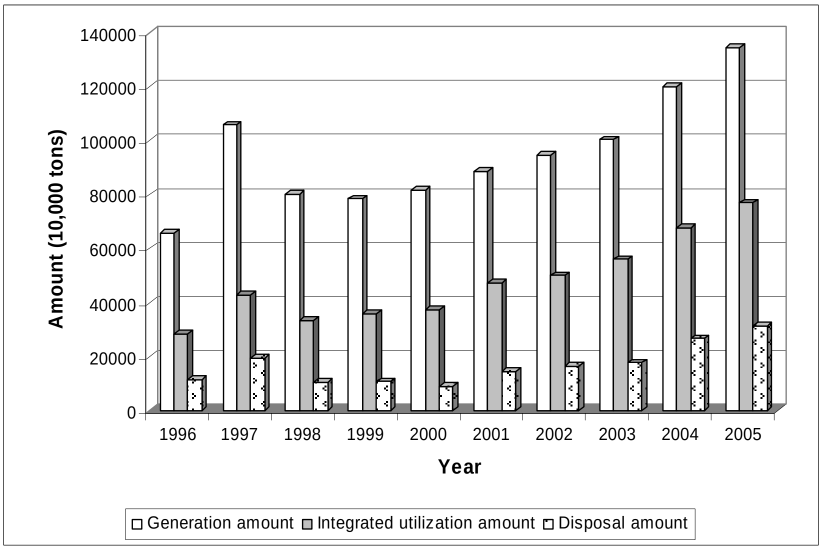

Fig.23: Industrial solid waste generation and management (1996-2005)

4. Sectors to be focused for CEM

Fig.24 showed the top 10 industrial sectors by their energy consumption intensities in 2005. Non-metallic mineral products used the largest amount of energy for per unit of added value. The key sectors in the decreasing order are smelting and pressing of ferrous metals, raw chemical materials & chemicals, petroleum & coking, smelting and pressing of non-ferrous metals, electricity production & supply, paper & paper products, etc.

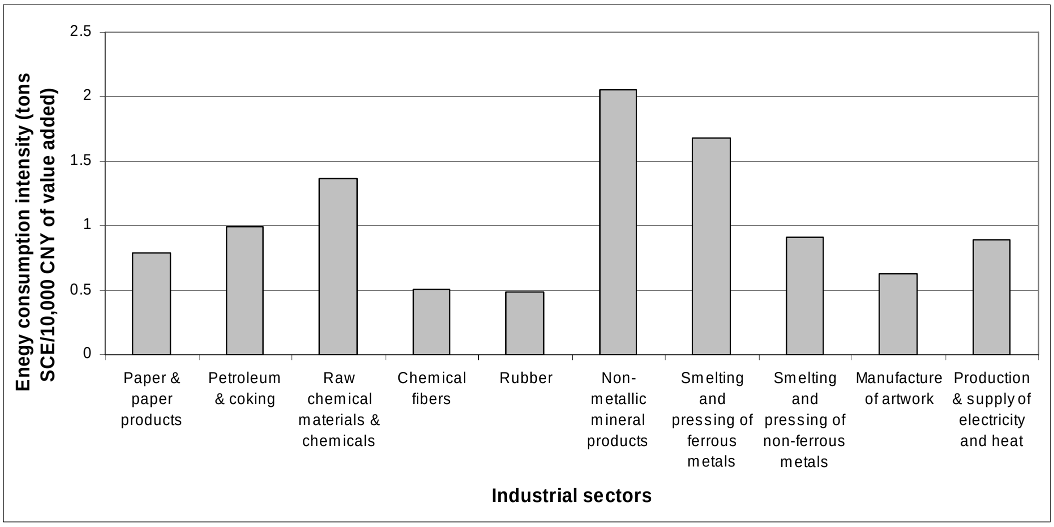

Fig.24: Top 10 industrial sectors based on the energy consumption intensity (in 2005)

Fig.25 listed top 10 industrial sectors based on the wastewater discharge amount in 2005. Pulp and paper industries discharged 17% of the total industrial sourced wastewater. The next industrial sectors included chemical materials and products, electricity and heat production, ferrous metals processing, agricultural food processing, and so on. The top five industrial sectors shared nearly 58% of the total wastewater discharge from industries. Similarly, the top nine industrial sectors by SO_2 emissions in 2005 were indicated in Fig.26. The production and supply of electricity and heat shared nearly 59% of the total SO_2 emission from industries. Non-metallic minerals producing, ferrous metals processing, chemical products manufacturing, etc. were also classified as major SO_2 polluters.

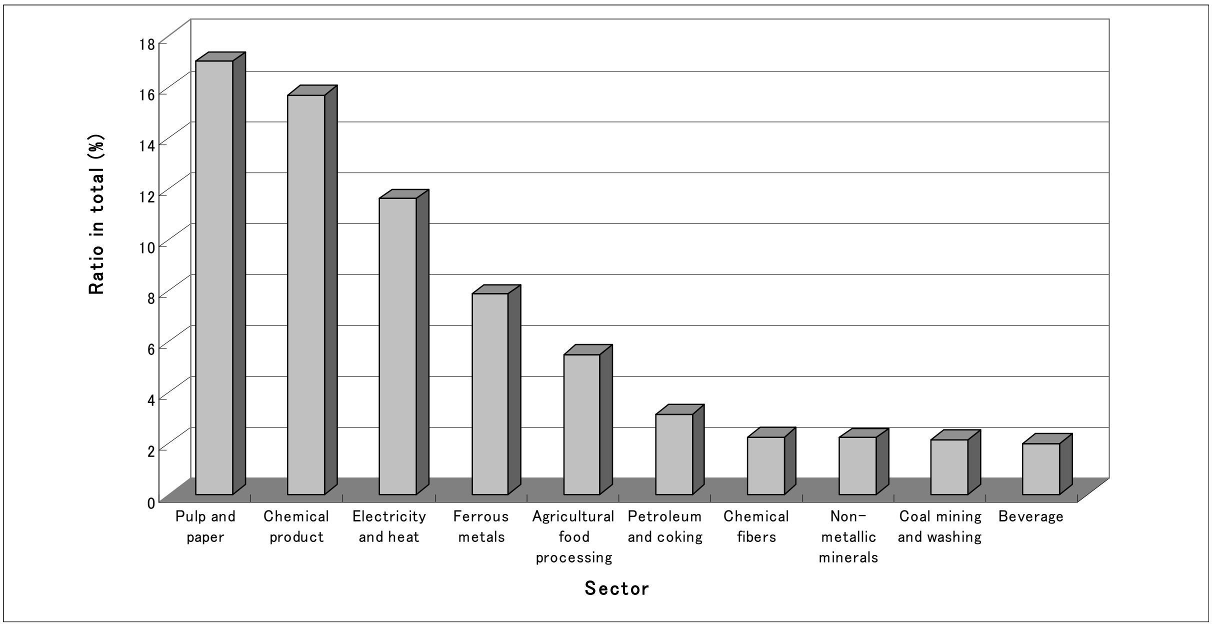

Fig.25: Top ten industrial sectors by the ratio of discharge amount of wastewater (2005)

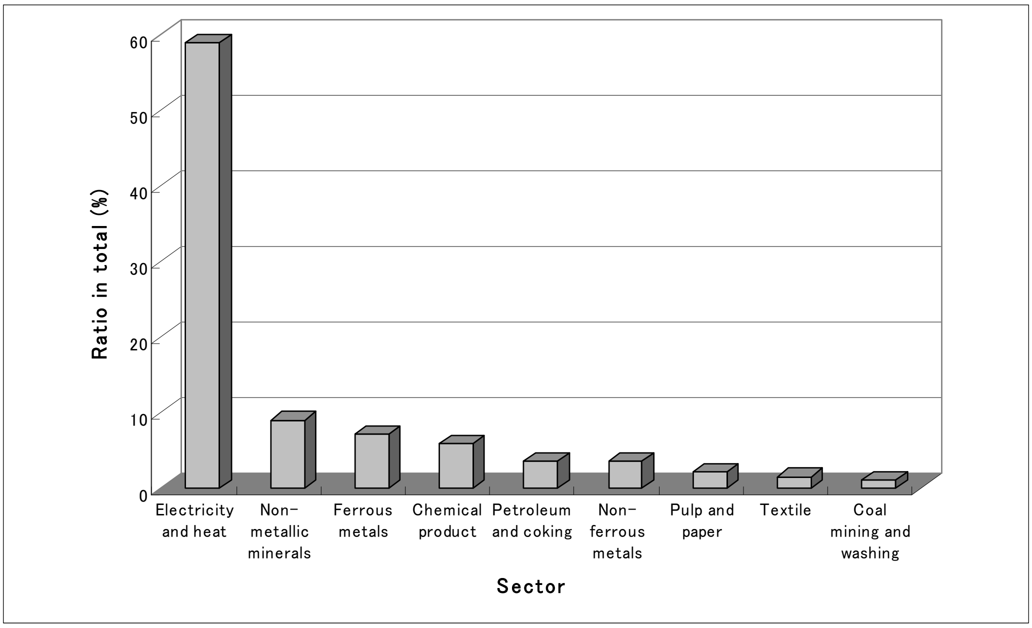

Fig.26: Top nine industrial sectors by the ratio of SO_2 emission (2005)

Based on above comparison of energy intensities and environmental load contributions of the industrial sectors listed in national statistic yearbooks, pulp and paper, textile, agriculture food processing, chemical product, non-metallic minerals, nonferrous metals, ferrous metals, petroleum and coking, and electricity and heat production & supply could be identified as key sectors with high environmental impacts. They may be selected as main targets for the studies aiming to enhance the CEM in China.

5. Environmental Governance in China

5.1 Environmental legislative framework

Over the last two decades, a relatively comprehensive environmental law and regulatory system have been established mainly by the Central Government of China. As indicated in Fig.27, subject to the Constitution of the People's Republic of China (PRC), the legal provisions related to the environment consists of laws, provisions, regulations, ministerial and local regulations. All of them are based on the Environmental Protection Law of the PRC. The laws and regulations, which form the legislative framework on environmental protection in China, can be classified as follows:

a) The constitution of the PRC [1982, revised in 2004]: Article 26 states that the nation protects and improves environment, and prevents pollution;

b) The Criminal Law of the PRC [1979, revised in 1999]: Article 9 states that who destroys environmental protection regulations should take penal offense;

c) The Environmental Protection Law [1989]: It is the basic law of environmental protection and was approved by the People's Congress of PRC;

d) Specialized Laws on environmental protection: such as prevention and control of water pollution, air pollution and so on;

e) The Environmental Impact Assessment Act of the PRC [2002]: It requires all major projects to implement an EIA and the EIA report must be approved by environmental protection agencies before launching the project;

f) The Cleaner Production Promotion Act of the PRC [2002]: Companies who produce excessive pollutants and who use or produce toxic materials must implement cleaner production auditing;

g) Laws on resource protection: With relevance to environmental protection such as energy conservation, forest protection and so on;

h) Provisions for environmental protection prepared by SEPA and other related ministries, and approved by State Council, providing guidance on implementing laws;

i) Ministerial level regulations released by the departments under State Council, e.g. SEPA, etc.;

j) Local provisions and regulations, seeking to address local particular environmental problems;

k) Environmental standards: including mainly environmental quality and emission standards, with most issued by SEPA but also including those issued by the provincial governments;

l) Multilateral Environmental Agreements (MEAs) to which China has agreed;

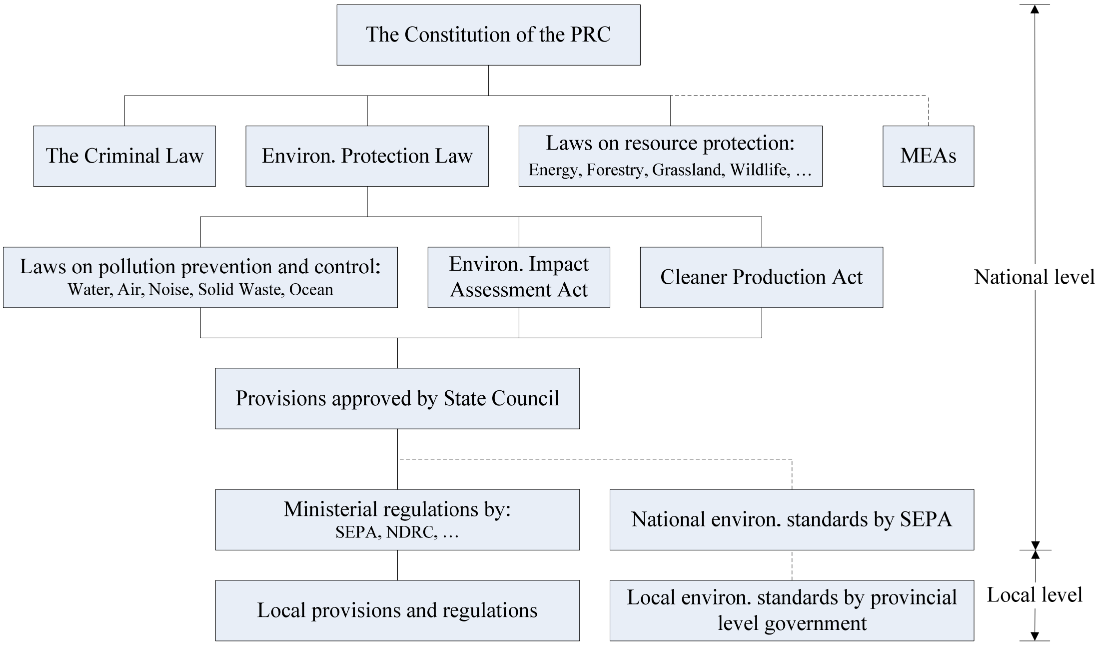

Fig.27: Environmental related legislative framework of China

5.2 Major environmental management systems

Various national policy systems have been also designed and implemented along with the development of environmental protection in China. They include: EIA (Environmental Impact Assessment), Three Synchronizations [2], Pollution Levy System, Pollution Control within Deadlines, Discharge Permit System, Environmental Responsibility System, Assessment of Urban Environmental Quality, and Centralized Control of Pollution *(Ma and Ortolano, 2000)*. Fig.28 sketched the eight environmental policy programs in more details.

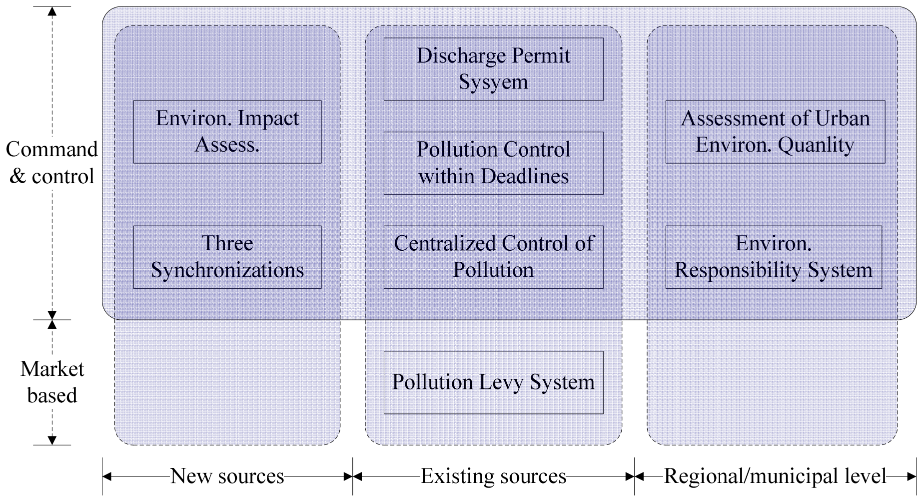

Fig.28: Major environmental management systems in China

---- [2] Three Synchronizations, one of the most significant national policies against the generation of new pollution, requires that all companies and government bodies synchronize the environmental management of all three phases -- design, construction and operation of a new project. This overall approach helps to prevent or minimize environmental impacts.

EIA and three synchronizations are mandatory requirements for the new sources. Pollution levy system, pollution control within deadlines, discharge permit system and centralized control of pollution are programs designed for the existing pollution sources. Environmental responsibility system and assessment of urban environmental quality are established to urge the leaders of local governments to take their responsibilities on the maintenance and improvement of environmental quality within their jurisdictions. Most of the management systems can be categorized as command and control measures. Pollution levy system is mandatory in China and can be also regarded as a kind of market based tool.

5.3 Institutional arrangement

5.3.1 National level

Currently, the following government organizations are involved in environmental protection at national level.

(1) ***The Environmental and Resource Protection Committee (ERPC) of the National People's Congress*** is responsible for developing, reviewing and enacting environmental laws. It is also in charge of supervising the implementation of environmental regulations and performance evaluation of the government in the environmental sector.

(2) ***A number of ministries and administrations of the State Council (other than SEPA)*** is involved in natural resource and environmental management, playing different but sometimes play critical roles in environmental management. Their areas of responsibility are summarized in Box1. One of the vice premier minister is responsible for environmental issues in the national cabinet.

(3) ***SEPA*** is the highest administrative body responsible for environmental protection within the government. SEPA is responsible for developing environmental policies, programs and standards and, to some extent, supervising local Environmental Protection Bureaus (EPBs). SEPA only deals with the activities that are of national significance. In all other cases, local EPBs implement industrial pollution control rules and deal with enterprises on a daily basis.

Fig.29 showed a whole image of the institutional framework of SEPA. Besides around 300 officials who are working in the 11 internal functional departments, there are more than 2,000 staffs working in affiliated research academies, institutes, organizational societies, or dispatched bodies which have functions of providing research and technical supports. In order to strengthen environmental supervision and enforcement, SEPA set up five regional supervision centers in 2006. Each of them has 30-40 staffs. Their main tasks are defined as monitoring the implementation of national environmental regulations at regional level, dealing with severe environmental violation cases, and coordinating the major environmental disputes between different provinces, etc. They may be regarded as the functional extension units of the Bureau of Environmental Supervision under SEPA. It seems still difficult for them to play effective roles due to the limited accessibility to the information of those potential targets for enforcement *(Xia, 2007)*.

Box1: Key government bodies involved in environmental management at national level

● ***National Development and Reform Commission (NDRC)*** develops the overall economic plans for the country, including environmental strategies and plans.

● ***Ministry of Finance (MOF)*** approves foreign loans and domestic financial allocation related to environmental projects.

● ***Ministry of Construction (MOC)*** is responsible for urban environmental issues, especially environmental infrastructures, such as water supply and wastewater treatment and municipal solid waste management.

● ***State Forestry Administration*** is responsible for forest conservation, afforestation, biodiversity and wildlife management.

● ***Ministry of Water Resources*** controls soil erosion, groundwater quality and carries watershed management outside urban areas.

● ***China Meteorology Administration*** has responsibilities in regional air quality management. It also takes part in the climate change negotiations.

● ***Ministry of Agriculture (MOA)*** is responsible for management of agriculture chemicals, aquatic natural reserves, agro-biodiversity and grasslands. It also regulates township and village enterprises.

● ***Ministry of Land and Resources*** is responsible for land us planning, mineral and marine resource management, and land rehabilitation. It is also responsible for mapping and cadastral (land ownership) management.

● ***Ministry of Communications*** shares responsibility with SEPA on vehicle emissions control.

● ***Ministry of Health*** is responsible for monitoring the quality of drinking water and the incidences of related diseases.

● ***Ministry of Science and Technology*** is the leading body in the development of environmental science and technology. It co-ordinates various environmental research programs in the whole country, including cooperation with international partners.

● ***State Oceanic Administration*** is responsible for management of coastal and marine waters, including marine biodiversity conservation.

5.3.2 Sub-national level

Due to the great heterogeneity in various regions of China, Chinese local governments have plenty of discretionary powers in local administration by directing local economic development and providing public services. Local EPBs are created from provincial to municipal and county level governments (see Fig.30). They are the major departments of local government responsible for making and implementing environmental regulations and dealing with enterprises. The people's congress at all levels make environmental statutes and review the work of EPBs. EPBs receive budgets from the corresponding local government and collect fees from enterprises under their jurisdiction such as the pollution charges.

Since these bureaus are part of local administrations (Governor's office) of the same level, SEPA has limited straight influences over EPBs although it does provide them with guidance on the implementation of policies and regulations. Only recently, SEPA acquired a right to comment for the nomination of the heads of provincial EPBs. Local EPBs should report to both an upper environmental protection department and the government to which they are belonging.

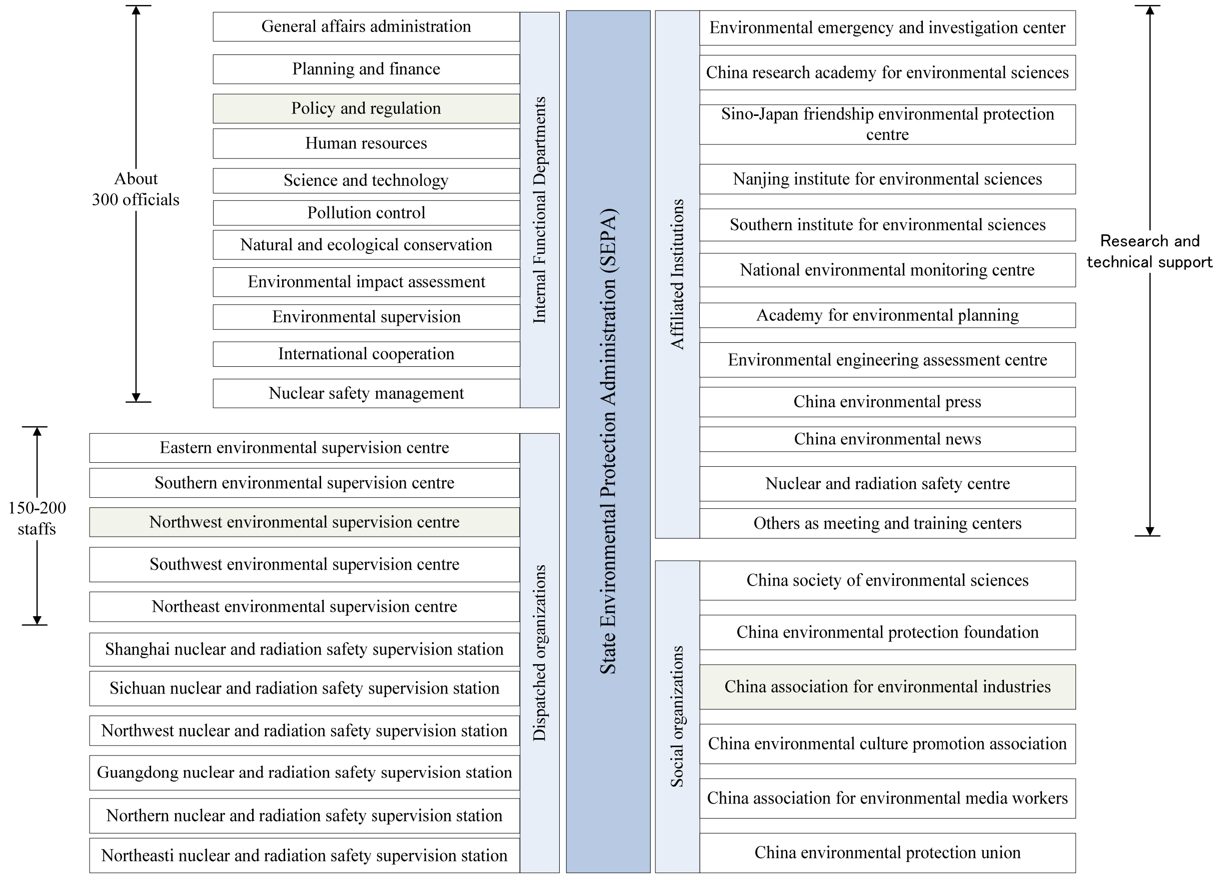

Fig.29: Institutional framework of SEPA

As SEPA at national level, the EPBs have a number of affiliated units such as an Environmental Monitoring Centre (responsible for ambient & emission monitoring), an Inspection Unit (responsible for enforcement & collecting emission charges), a Research Institute (responsible for technical analysis & research). Most of these units are public service units (PSUs).

The main responsibilities of local EPBs include:

- Overseeing environmental impact assessment and other procedures for new development projects;
- Monitoring pollution releases from industries;
- Assessing fees for pollution charges;
- Initiating legal actions against firms that fail to meet environmental requirements;
- Environmental reporting, environmental education and awareness raising activities, etc.

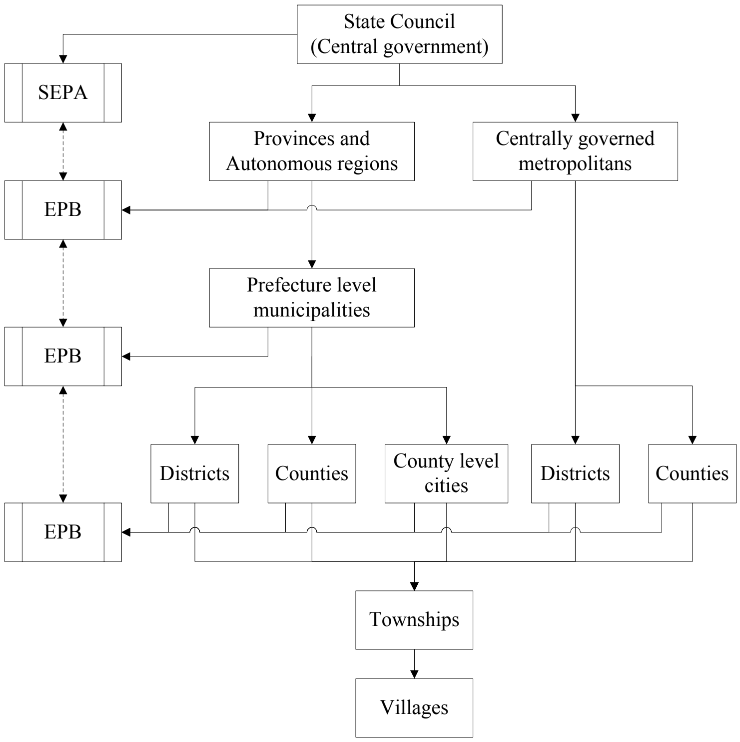

Fig.30: The sub-national institutional structure for environmental policies implementation

Both the number of environmental organizations and the staffs have grown fast in the past 10 years, especially in the second half of 1990's. There were 166,774 staffs working in the 11,528 organizations for the environmental protection by the end of 2005 (see Fig.31).

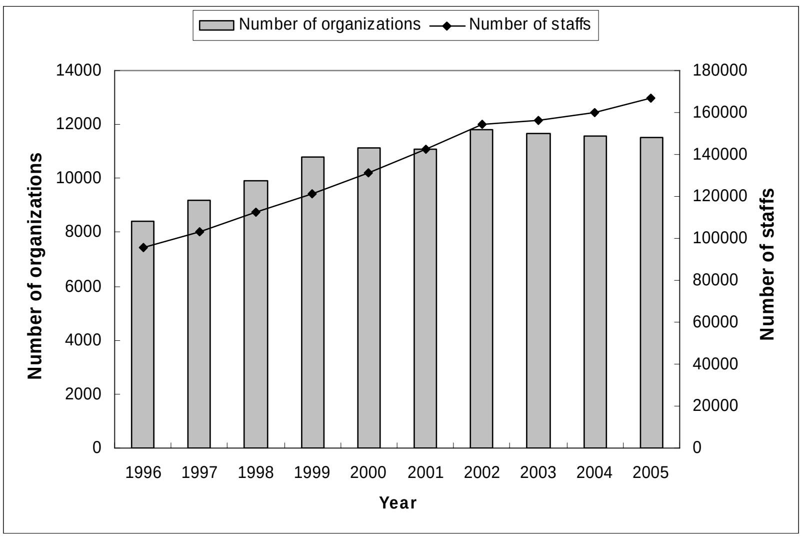

Fig.31: Number of organizations and staffs of environmental protection at all levels (1996-2005)

6. Current Status of CEM in China

6.1 Generalized framework of CEM at firm level

Fig.32 showed a good example of institutional framework for environmental management in a company in China. A specific board for environmental management is set up within the company. The

CEO is the director of the board and the leader on duty for environmental management. The environmental department acts as administrative wing of the board. The members of the board are the head or representative of each department or production unit. Under the board, there are several sub committees which are looking after the main environmental impact factors of the company such as energy conservation, waste reduction, and chemicals management, etc. The sub committees are headed by the staffs on duty from environmental department and made up of the representatives from other related departments. This institutional arrangement at firm level addresses the responsibility of the top leaders on environmental problems, and the participation of all the units concerned in the company.

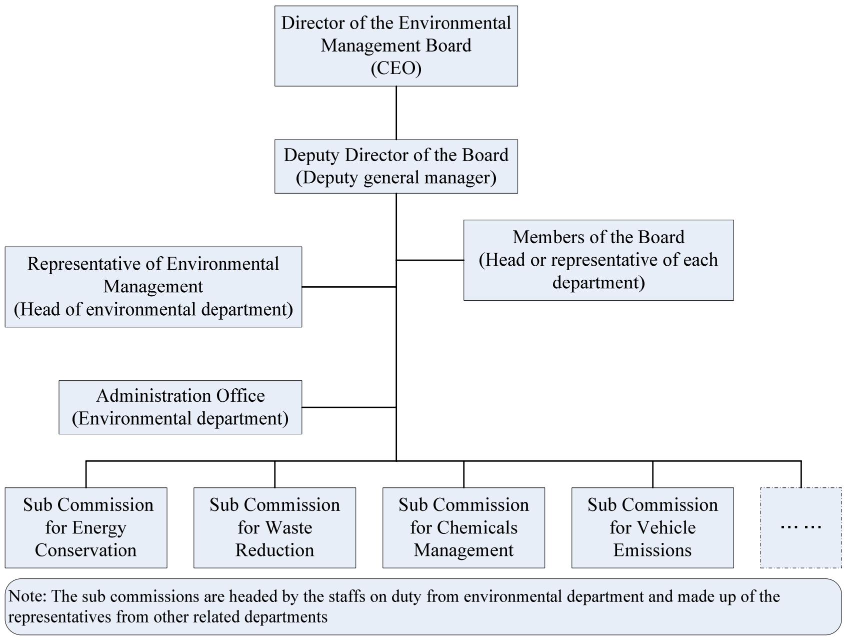

Fig.32: An example of institutional framework for environmental management at firm level in China

6.2 Environmental compliance and enforcement

The monitoring and inspection of industrial facilities in China, as indicated in Fig.33, follow a precise procedure. Apart from regular inspection activities, note that complaints made by citizens regarding environmental incidents may raise field inspections. If the polluters are found at fault, various administrative penalties may then be imposed. These may also include the request for the polluter to install treatment facilities. In extreme cases, the plant may be ordered to cease and relocate its operations.

Even though several types of non-compliance sanctions are used by environmental authorities, a wide gap exists between what EPBs are authorized to apply and what they actually do when enterprises violate environmental rules. In many cases, industrial polluters are more interested in saving the operation costs. The installed pollution control equipments are put in operation only at times when inspectors' visits are expected. A significant proportion of small and medium sized enterprises are not often inspected due to the lack of capacity or conflicts of interest between economic and environmental sections of the administration. Pragmatic enforcement also pushes EPBs to target big polluters first and leave SMEs untouched although their aggregated pollution volume may be much larger. Further, some local governments prohibit the environmental authorities to inspect and impose fees and fines on firms which are significant pollution contributors but are regarded important to the local economy in terms of providing tax and employment. This kind of interference renders environmental enforcement ineffective.

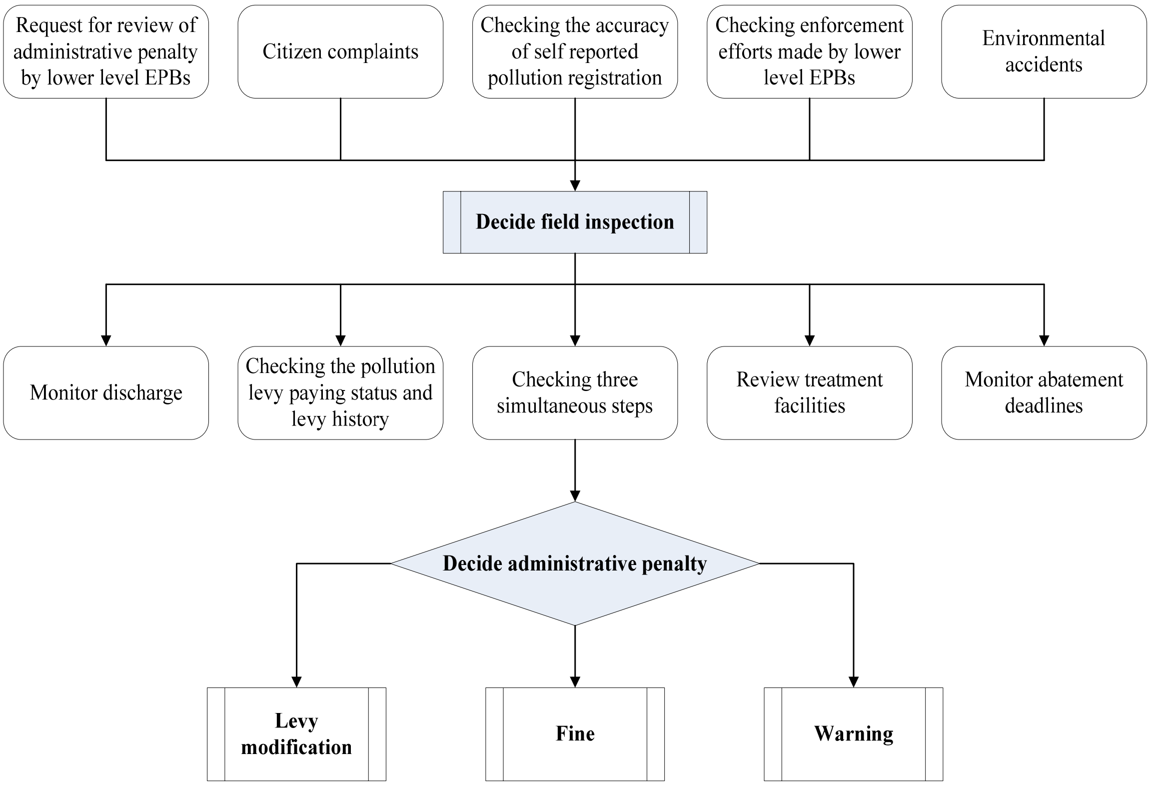

Fig.33: Procedures of field inspection to industrial facilities

As the result, the violation cases appeared to be increasing nationwide during 1998-2005 although the penalties to illegal environmental activities are becoming heavier. The environmental violation cases were about 40,000 in 1998. This number soon doubled and was around 90 thousand cases in recent years (see Fig.34).

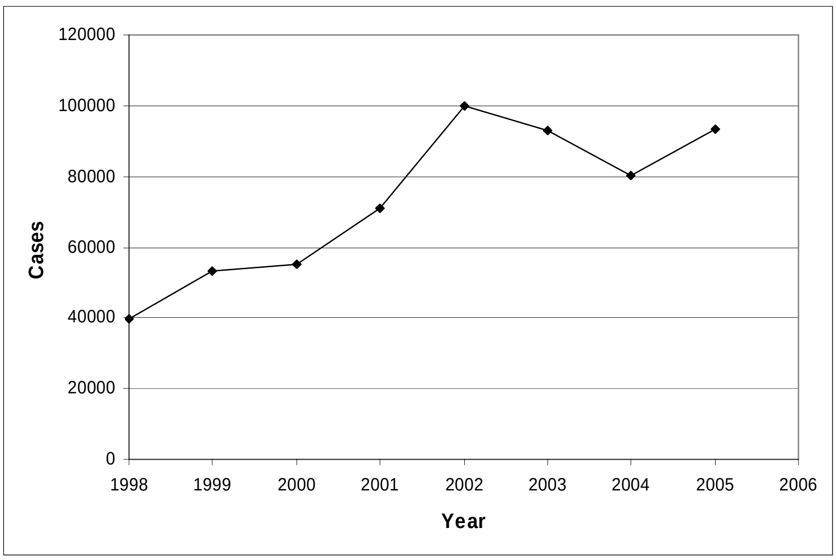

Fig.34: Penalty cases to environmental violations of enterprises (1998-2005)

6.3 Market-based instruments

To complement the regulatory system, economic instruments have been adopted to curtail environmental pollution from industries in China. Discharge fee is calculated based on the concentrations and types of the pollutants in the effluents. These are applied to industrial emissions covering discharges of wastewater, waste gases, solid waste, noise and low-level radioactive waste. Pollution levies are collected by local EPBs with jurisdiction and earmarked for environmental protection purposes. As indicated in Fig.35, the pollution fees charged during 1996-2005 increased quickly, especially after the enacting of new "Ordinance on the Management of Pollution Fee Charging and Utilization" in 2003. The total emission fee charged in 2005 reached 12.32 billion CNY.

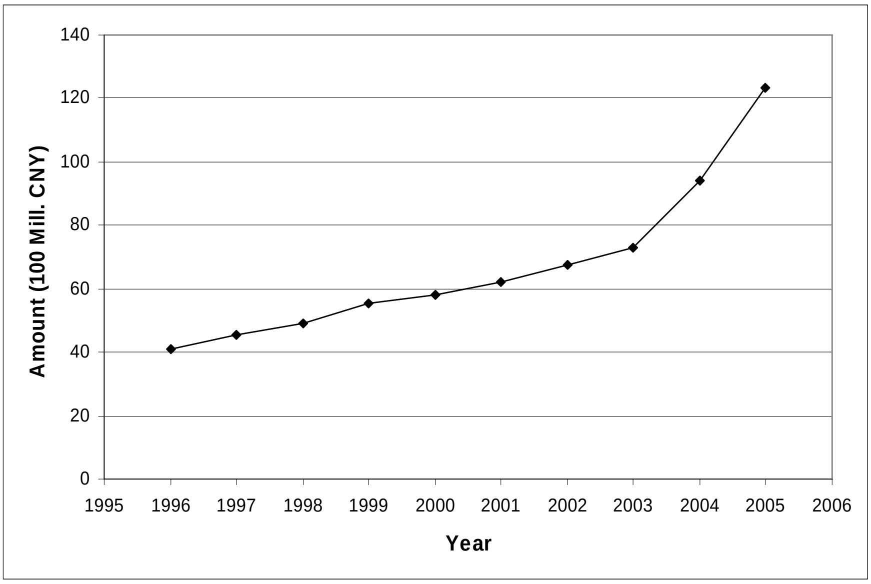

Fig.35: Pollution fee charged during 1996-2005

Other economic instruments have also been introduced. Since 1989, an ecological damage compensation system was introduced in some places. Pilots of SO_2 tax and charges for the treatment of end of life products have been undertaken in some provinces and cities. The application of these instruments will be expanding over time.

In addition, financing mechanism for environmental protection has been set up by the government. These include: funds for enterprise expansion and redevelopment, municipal maintenance funds, earmarked grants from revenues supported by the pollution levy, and provision for retention of enterprise owned profit resulting from waste reuse and access to bank credits.

Supported by the growing economy, direct investments on the establishment of pollution control facilities increased dramatically in the last 10 years (see Fig.36). The investment amount was 9.56 billion CNY in 1996, which reached 45.82 billion CNY in 2005. The investments for water and air pollution control were growing steadily. They shared more than 75% of the total investment. On the growing curves, a sudden increase of investment on pollution control of the enterprises in operation occurred in 2000. It was because of a mandate issued by the central government in 1996 which required all the industries must meet national or local environmental discharge standards by the end of 2000. This kind of Chinese specific environmental enforcement campaign sometimes did play certain roles.

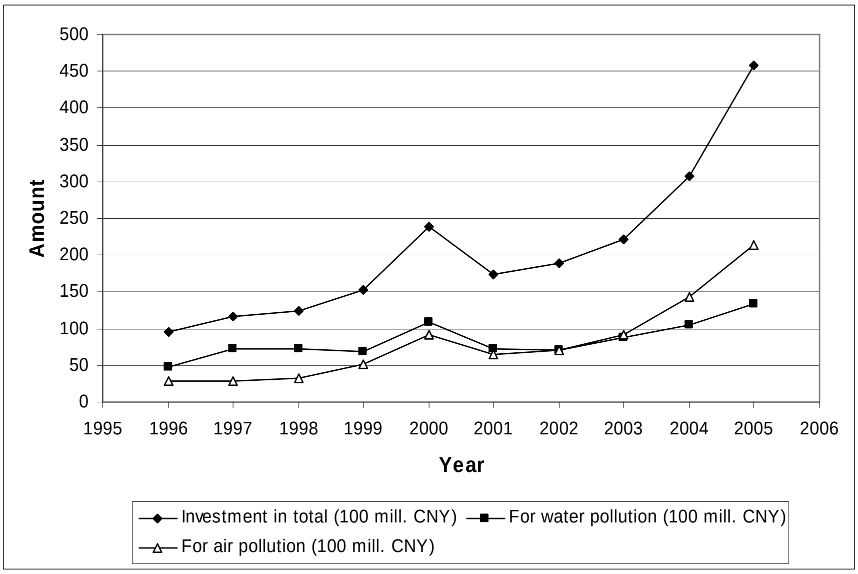

Fig.36: Pollution control investment for the enterprises in operation (1996-2005)

6.4 Informal measures for promoting environmental compliance

SEPA and some local EPBs evaluate industrial performance within their jurisdictions and name excellent performers "environmental friendly" or "green" enterprises. From 1989 to 1997, this kind of assessment had been conducted 6 times, and 500 enterprises were awarded the title of the "National Advanced Enterprise on Environmental Protection". Most of them have been removed from the list over time for failing to meet the standards. The effect of such program seems limited since there is lack of follow up measures to enable the excellent environmental performers to capitalize on their environmental friendly behaviors.

Other compliance promotion tools include provision of subsidies for wastewater treatment facilities, faster approval of upgrading or expansion of pollution control installations, and lower inspection frequency, etc. Overall, compliance promotion in China is less developed than punitive measures. The EPBs seldom provide technical assistance to help the industrial polluters clean up, and rarely impose compliance schedules with differentiated penalties to induce polluter to come into compliance or perform even better.

6.5 Voluntary based initiatives

6.5.1 ISO14001 certification

Fig.37 showed the development of ISO14001 certification in China. In 1996, Chinese central government started to study the new issued ISO14001 standard and launched pilot certification. Till 2002, the national accreditation system for ISO14001 certification was established and the number of certified enterprises steadily increases from then to 2,803 enterprises by the end of 2002. EMS certification expanded very fast in the last 5 years. 18,979 organizations achieved the certification by the end of 2006. This made China ranking the 2nd in the world by the number of ISO14001 certificates, following Japan *(Li, 2007)*.

The five sectors holding the most of ISO14001 certificates are: construction; service; electrical and optical equipment; chemicals, chemical products and fibres; rubber and plastic products by 2006 (Fig.38).

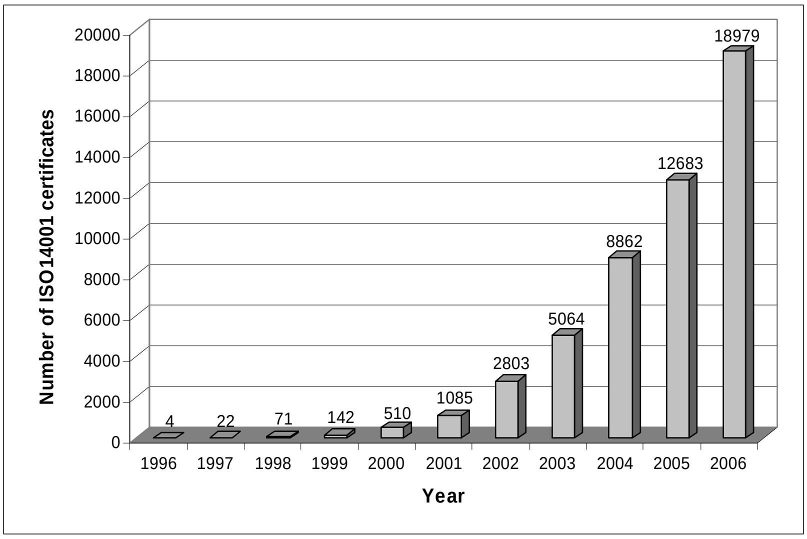

Fig.37: Growth of ISO14001 certification (1996-2006)

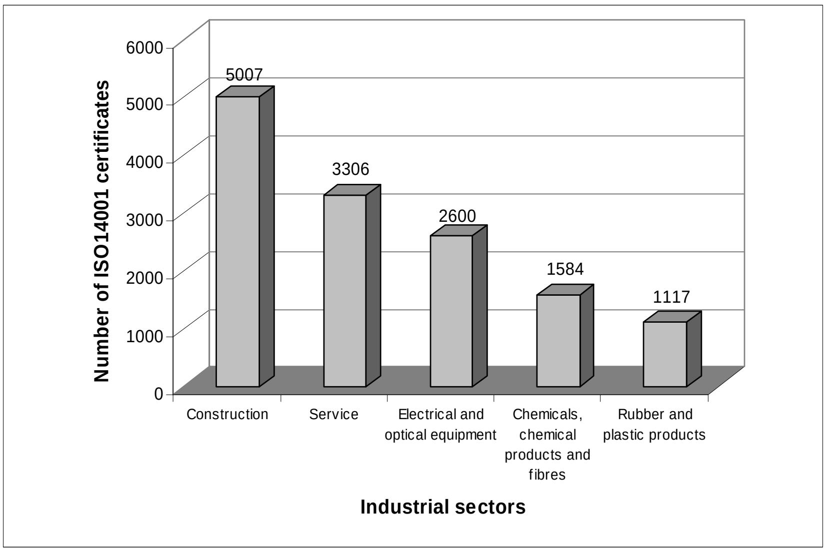

Fig.38: Top five sectors with ISO14001 certificates (as of the end of 2006)

6.5.2 Eco-labeling

As a voluntary certification scheme, the purpose of China's Environmental Labeling Scheme is to recognize the efforts of producers on environmental friendly products and enhance environmental awareness of the consumers. The China Certification Committee for Environmental Labeling of Products (CCEL) was formed in 1994 by SEPA, the State Bureau of Technical Supervision and the State Administration of Import and Export Inspection and Quarantine (In 2001, later two agencies were combined into present General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China). The Secretariat of CCEL is authorized by SEPA as the only organization to conduct the third party certification and award the China Environmental Labels. Annual inspection and random sampling are carried out to ensure that appropriate standards are met. Between 1994 and 2005, assessments have been conducted in 800 enterprises, and 12,000 products have been awarded China Environmental Labels. The enterprises holding environmental labels gained a competitive advantage in domestic and international trade. In order to increase the impact of the labeling scheme, the criteria developed for the labels should be more stringent, transparent and comparable with international good practices.

6.5.3 Cleaner production

Cleaner production (CP), as the environmental preventive practice and a win-win approach, came into China systematically from the 1990's. In response to the United Nations Conference on Environment and Development in 1992, China has devoted fully to the sustainable development strategy including the preventive CP measures. In China's Agenda 21 published in 1994, CP was further regarded as a key strategy for achieving national goals of sustainable development, from which CP was introduced in China and began to be implemented in industrial sectors, though mostly as pilot projects. Generally, CP practice in China can be viewed as two phases. The earlier one, from 1992 to 1997, focused on the introduction of methodology, personnel training and demonstration auditing; while the second one, since 1997 up to now, is characterized as policy study, formulation and implementation.

In the first phase, publicity and training materials were developed for the Chinese users. The influencing ones include the monograph of "Cleaner production – concept and practice", "Manual for cleaner production auditing" and "Guideline for implementing cleaner production". Training programs, which were often incorporated with CP pilot projects, had been carried out for managers and technical staffs in enterprises and industrial sectors. A preliminary institutional framework had been established, which consists of China National Cleaner Production Center, local CP institutions currently available in some regions, and CP institutions created in some industrial sectors as petrochemical, chemical, metallurgical, and light industry, etc. Implementation of pilot projects, based on CP auditing at firm level, was a major activity in this phase. These projects were mostly carried out via bilateral cooperation, which were funded by USA, UK, Australia, Canada, EU and UNDP, and were implemented in different geographical areas of China.

In spite of the high willingness to CP and the significantly potential benefits from CP as illustrated by CP pilot projects, dissemination of CP has been far less effective as expected due to the barriers inside and outside of the enterprises. In order to promote CP over the long term, establishment of policy mechanism was expected through a series of policies studies in the second phase. Major of these studies included: (1) a study conducted by the special CP working group under China Council of International Cooperation on Environment and Development (CCICED) in Taiyuan city of Shanxi province; (2) the policy study as part of a CP project funded by Canadian International Development Agency (CIDA) to assist China in implementing CP in key industrial sectors; (3) The third study supported by the Asian Development Bank (ADB), in the context of "Technical Assistance Cluster Project for the Promotion of Clean Technologies". The fundamental objective of this project is to improve national policies, institutional capacity and financing mechanisms for CP. Based on the studies outlined above, a wider range of policy options was developed through barriers identification, surveys, case studies and reviews of China's current environmental policies and regulations, as well as its technological renovation strategies. The CP policy framework, which composes of compulsive, incentive and supportive mechanisms, was regulated into the CP Promotion Law of the PRC issued in 2002 and enacted from January 1st of 2003.

As a result of the effort, China is recognized as a developing country which has placed particular emphasis on advances in CP *(Duan, 2003)*. Several studies show that CP practices have led to a reduction of pollution by enterprises and production efficiency. Some estimates show that they contributed to a 20% reduction of emission from the enterprises while generating economic returns of 5 million CNY annually in average.

6.5.4 Cycle economy and eco-industry

In less than three years since 2003, the concept of cycle economy (CE) and eco-industry was introduced into China and started to flourish. The theme of the CE concept is the exchange of materials where one facility's waste, including energy, water, materials as well as information may become another facility's input. By working together, the community of businesses seeks a collective benefit that is larger than the sum of the benefits which each enterprise, industry and community would realize on an individual basis. Development of eco-industries based on the theory of circular economy is essential for China to reach an overall well-off society by sustaining fast-paced economic growth while mitigating negative ecological impact and creating more job opportunities.

To encourage eco-industrial initiatives in China, SEPA has supported experiments in eco-industrial development. As of May, 2007, SEPA had encouraged 26 demonstration sites of pilot eco-industrial clusters to come into existence *(SEPA, 2007b)*. These include 26 potential eco-industrial parks (EIP), one demonstration city (Guiyang city), and one demonstration province (Liaoning province) for CE at national level (see Fig.39 for the locations of the pilot programs).

With regard to fundamental organization, the pilot study sites fall into two categories: enterprise management and government management. Thus Baotou, Guigang, Fushun, Lubei, Antai and Qingdao Xintiandi are managed by enterprise groups while other candidate EIPs are managed by the Management Commission of the Development Zone, which is the local municipal agency. The Guiyang city and Liaoning province demonstration sites for CE are managed by local government directly. Regarding to the regional scale, the total 28 pilot study sites fall into three categories: small (26 EIPs), medium (one demonstration city) and large scale (one demonstration province). This provides a basis for seeking ways to link different producing processes, plants and industries as well as consumers into an operating platform to minimize the industrial materials that go to final disposal sinks or are lost in intermediate processes at larger spatial scales *(Fang, 2003)*.

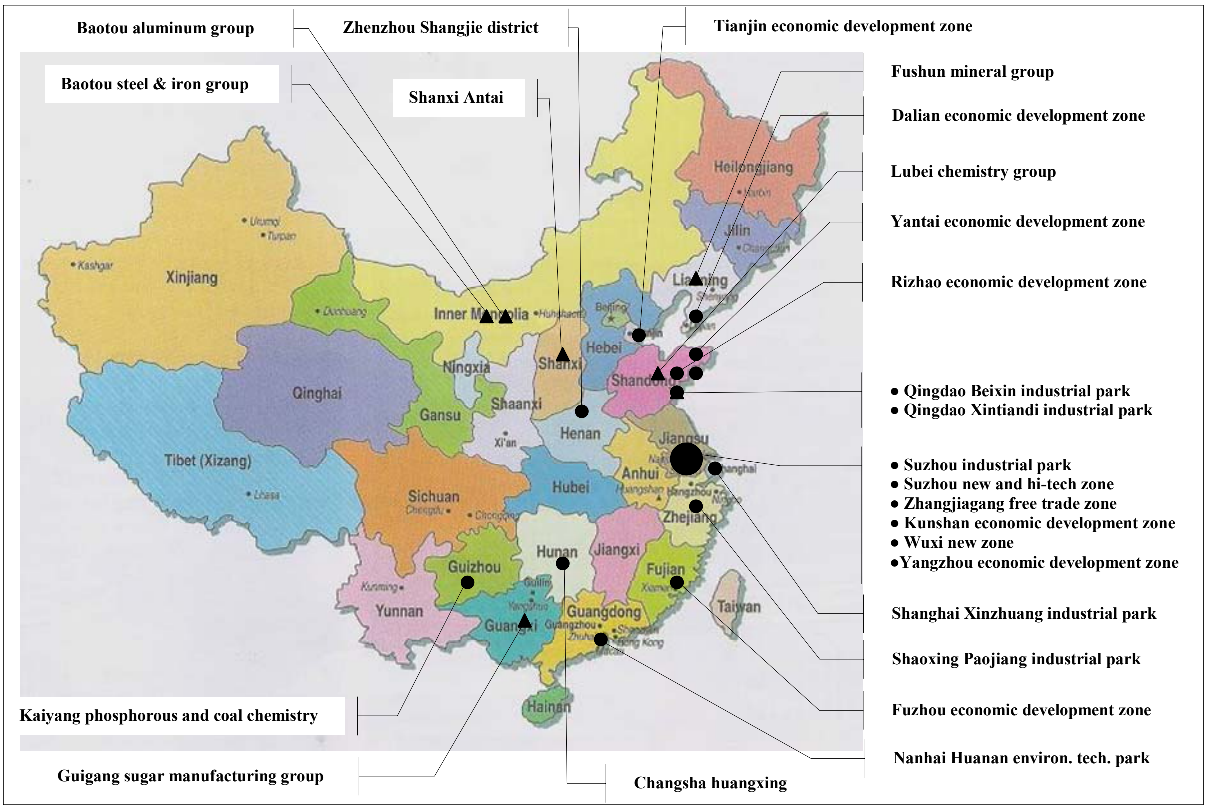

Fig.39: Schematic diagram of the locations of national eco-industrial development projects

7. Perspectives of CEM in China

Five-Year Social and Economic Development Plan (FYP) has been the basis for coordinating Chinese public policy priorities. These have been developed by Chinese government and approved by the Chinese Communist Party and the National People's Congress. In line with FYP, the Chinese environmental authorities have developed Five-Year Environmental Plan (FYEP). The FYEP is further broken down into sector five year plans. Goals set in the national plans constitute the basis for provincial and local government to prepare their own environmental plans at local level. The 11th FYP (2006-2010) was adopted in March, 2006. Moving away from planned economic and production targets, this document set broader and ambitious goals and planned a set of public investment projects. Some environmental targets were identified in the overall Social and Economic Plan (see Box2)

Box2: Environmental targets in the 11th FYP (2006-2010)

● ***Reduce energy intensity by 20%;***

● ***Reduce water consumption per unit of industrial value-added by 30%;***

● Maintain water consumption for irrigation in agriculture at current level;

● ***Increase recycling of industrial waste by 60%;***

● Retain the area of farmland at 120 million hectares;

● ***Reduce the total discharge quantity of major pollutants by 10%;***

● Reach forest coverage of 20%;

● Control greenhouse gases to "generate good results".

7.1 Industrial restructuring

The current production structure is irrational in China. The production capacities appear to be surplus but at low quality in some industrial sectors or geographical regions. The enterprises are consuming large amount of energy and natural resources which causes high cost of the products and high burden to the environment. Most of the Chinese enterprises are small and medium sized. Additionally, many enterprises are using less advanced or even out of date producing technologies which lower the competence of the enterprises. Economic growth of China is mainly driven by industrial manufacturing, in which heavy industries have a big share. This kind of economy has to rely strongly on the huge consumption of energy and resources which will definitely cause severe environment problems. The adjustment of industrial structure is expected to play a key role for energy conservation and emission mitigation in the 11th FYP.

The indicator of energy consumption of per unit of GDP has been regulated by NDRC as a kind of mandatory index. On the fixed capital investment, the project will not be approved if it can not pass the check on the performance of energy conservation. SEPA even suspended the approval to all the new projects in certain listed regions to restrain the expansion of industries with high pollution and energy consumption *(SEPA, 2007c)*.

7.2 Greening the industries by a combined approach

Based on above glance at the history of environmental management of industries in the last two decades in China, compulsory enforcement is the dominate measure. The governments at different levels actually provided limited supportive assistance to the enterprises by promoting the dissemination of good pollution control practices or giving a few financial aids. Economic incentives are not effectively used to encourage the industries to improve their environmental performances. The industrial polluters felt growing but still insufficient pressures from the neighboring communities and other social stakeholders. Along with the time going, economic tools and social pressures could also become prior factors for enterprises to improve their CEM performances.

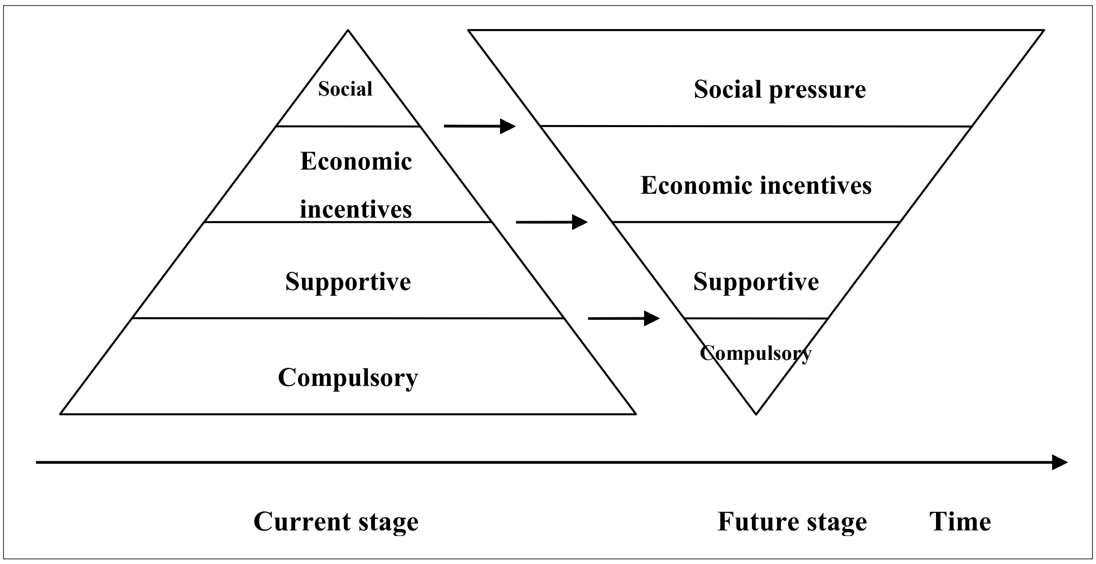

Fig.40: Structure evolution of integrated environmental management policy mechanism

As Fig.40 indicated, China should adopt a combined approach which is more effective from a long run for the solution of the complex environmental problems. More measures should be studied and introduced which could create sufficient pressures from economic or social aspects to those enterprises which are laggard for environmental compliance.

Market based tools are suggested to play more roles for energy conservation and emission mitigation besides enforcement efforts. Several economic policies such as green taxation, green credit and ecological compensation, etc. are requested for study by the top leaders of SEPA *(Pan, 2007)*. Environmental economic policies may become hot research topics for China in near future.

7.3 Emerging approaches for CEM in China

There are several new approached recently emerging in China to enhance the performance of CEM. The basic principle is to introduce more related actors to give more pressures for the laggard enterprises or more incentives to the enterprises who are performing well.

7.3.1 Performance rating scheme by environmental information disclosure

Recently, central and local environmental agencies have been using a more systematic mechanism for disclosure of environmental information to influence environmental behavior of enterprises. An example is the application of an environmental performance rating and information disclosure scheme initiated by SEPA currently. After doing pilot programs in two typical municipalities together with experts from World Bank, SEPA issued a guideline to promote the information disclosure program nationwide in November 2005 since the positive reactions were observed. The color rating for each individual enterprise is compiled based on three major data sources: self-monitoring pollution data; administrative records; and surveys on firm specific characteristics. More specifically, the rating system incorporates data on emissions of 13 regulated air and water indicator pollutants. Solid wastes are rated by the generation, disposal and recycling. Besides pollution discharge, firm’s environmental behavior is taken into account in the following two dimensions: relations with regulator; and internal environmental management. In more detail, the following elements are considered: timely payment of pollution charges, implementation of National Pollution Discharge Reporting and Registration Program, internal environmental monitoring, staff training and record keeping, energy and resource efficiency, and so on. The rating scheme is comprehensive and offers participating enterprises an opportunity to discuss the result with the authorities before disclosing it to the public.

Although some local governments tend to conceal information on poor environmental performance of enterprises within their jurisdiction, the compliance performance rating system is used by the banks as a guide for giving loans to individual enterprises in some provinces. This system may well prove to become a persuasive instrument to foster greater environmental responsibility in industry.

7.3.2 New economic measures

SEPA is also making efforts to stimulate enterprises to improve their environmental performances by introducing new economic tools. In July of 2007, SEPA co-issued an announcement on the implementation of environmental regulations and prevention of loan risks with the People′s Bank of China and China Banking Regulatory Commission. Environmental protection departments at all the levels are required to provide information listed in Box3 to related departments of finance. These departments are required to merge the information into the credit database of enterprises. The loan can not be granted to the new projects which are against national policies. The monetary departments should strengthen credit management and control loans to the environmentally illegal enterprises.

Box3: Environmental information provided to monetary departments

● Results on the checking and approval of EIA report, and on the environmental protection checking for the completion of construction projects;

● List of heavy pollution enterprises whose pollutants emission exceeds national or local discharge standards, or whose total emission amount is higher than the amount ratified by local government;

● List of enterprises which have caused severe environmental pollution accidents;

● List of enterprises which refused to implement the effective environmental penalties;

● List of enterprises which are required to control the pollution within deadlines and which are ordered to be shut down;

● List of environmental friendly enterprises;

● Information on the assessment of enterprise environmental performance;

● Others necessary to inform monetary departments.

8. Summary

CEM in China should be improved greatly due to currently severe pollution and poor performances of manufacturing industries. Those industrial sectors which have high environmental impacts should be paid more concerns. Legislative and administrative measures have played active roles but appeared to be far sufficient for actual needs. Most Chinese enterprises tend to reactively response to environmental regulations and enforcement actions. Mandatory enforcement campaigns can not effectively resolve the industrial pollution problems. Other complementary policy measures such as market based instruments and informal policy tools should be studied. In order to testify the effectiveness of the optional policies or business strategies, the major factors for the decision making process of enterprises on environmental issues should be identified. The relationship between CEM behaviors and corporate economic performances should be quantitatively evaluated by case studies.

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