

# Chapter 9

## Green Development and Environmental Carrying Capacity

Xianqiang Mao, Rui Hou and Peng Song

Earlier studies on Carrying Capacity are closely related to the development of Ecology. In 1921, Park and Burgess proposed the concept of Carrying Capacity in their work in Human Ecology, i.e. ‘the maximum limit of the number of individual organisms in existence, in a particular environmental condition (mainly refers to the living space, nutrients, sunlight and other ecological factors in combination)’. This term was then used in environmental science academy in China, i.e. ‘Environmental Carrying Capacity’, reflecting the interaction between intensity of human activity and environment.<sup>1</sup>

‘Environmental Carrying Capacity’ in this chapter is focused on human activity, namely the threshold of the ability of environmental system to support human activities, which is a function of time, space and economic behavior. Focused on ‘Green Development and Environmental Carrying Capacity’, this chapter aims to discuss how to ‘reasonably use the carrying capacity of environment, improving environmental carrying situations and conditions, and thereby improve the quality of the environment’.

In this chapter, we will use the indicator of ‘Pollution-Economy Time Elasticity (PETE)’, i.e. the ratio of the annual percentage variation of pollution indicators over the annual percentage variation of economy indicators in a specific country or region, to reflect the relationship between pollution and economy growth and to reveal the dynamics of pollution and economic development, thereby to reflect the environmental efficiency of economic growth.<sup>2</sup> ‘Green Development and Environmental Carrying Capacity’ in this chapter more refers to a ‘flow’ than a ‘stock’. Therefore,

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<sup>1</sup> GUO Xiurui, MAO Xianqiang, RAN Shenghong. Research Progress in Environmental Carrying Capacity in China [J]. *China Population, Resource and Environment*, 2000(3), 28–30.

<sup>2</sup> MAO Xianqiang, YANG Shuqian. The Concept, Method and Application of the Pollution-Economy Time Elasticity (PETE) [J]. *China Population, Resource and Environment*, 2010(11), 156–160.

PETE is used to depict the dynamics of national or regional ‘Green Development and Environmental Carrying Capacity’.

## 9.1 Environmental Carrying in China’s Green Economic Development in the 11th Five-Year Plan Period

In the ‘The 11th *Five-Year Plan* for National Economic and Social Development of the People’s Republic of China’ approved by the Fourth Session of the Tenth National People’s Congress in March 2006, it was clearly advanced to reduce the energy consumption per unit GDP by 20 percent, and total emission of major pollutants [sulfur dioxide (SO<sub>2</sub>) and chemical oxygen demand (COD)] by 10 %. This was identified as binding targets of the economic and social development in the 11th *Five-Year Plan* and was a milestone in the history of Chinese environmental protection.

### 9.1.1 Environmental Quality

In the period of 11th *Five-Year Plan*, China’s economy developed stably with an annual GDP growth rate of 11.2 %, much higher than the world economy, and 1.4 % faster than the growth rate in the “10th Five-Year Plan” period, registered as one of the fastest periods since China’s Opening and Reform. The continuous rapid growth of economy has brought great pressure on resources and the environment.<sup>3</sup> Under the leadership of the central government, in the 11th *Five-Year Plan* period, China had promoted the development of environmental protection through the construction of resource-saving and environment-friendly society to accelerate the transformation of economic development. In the last 5 year plan period, China’s environmental protection efforts and pollution control investment maintained rapid increase. The total discharge of major pollutants has been under control; the prevention and control of environment pollution has obtained stage achievement; ecological protection has been strengthened comprehensively, and environmental quality has been improved substantively. In 2010, in the water quality monitoring sections in the seven major river systems, I-III water quality grades accounted for 59.6, 18.6 % higher than that in 2005; of the cities under air quality monitoring, 82.7 % met Grade II or above, a 22.4 % increase over 2005. At the end of 2010, the daily processing capacity of the city sewage treatment

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<sup>3</sup> National Bureau of Statistics, Series report No.1 of the development achievement for the “11th *Five-Year Plan*”: New Development, New Leaps and New Chapter”, March 1, 2011. [http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301\\_402706119.htm](http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301_402706119.htm).

plant reached 102.62 million cubic meters, or increased by 79.2 % compared with that of the end of 2005. City sewage treatment rate reached 76.9 %, or increased by 24.9 %.<sup>4</sup>

The improvement of environmental quality is closely related to the increase of the investment in environmental protection. During the period of 11th *Five-Year Plan*, China has adopted a series of policy measures to further broaden the financing channel of investment in pollution control, and to strengthen the prevention and control of environmental pollution management. As a result, investment in pollution treatment has maintained rapid increase, especially in some key areas. In 2009, total investment in environmental pollution control was 452.5 billion Yuan, increased by 89.5 % over 2005. Environmental pollution control investment as a share of GDP has increased from 1.30 % in 2005 to 1.33 % in 2009. Among them, the city environmental infrastructure construction investment was 251.2 billion Yuan, increased by 94.8 % over 2005. The growth rate of the investment in city gas, central heating, drainage, landscaping and sanitation was 27.9, 67.4, 98.3, 122.4 and 114.1 % respectively. The investment on “three simultaneous (pollution prevention and control measures must be designed, constructed and put into use at the same time with the main project)” project was 157.07 billion Yuan, or 1.5 times more than that in 2005 (Table 9.1). In 2009, the investment in fixed assets was 135.1 billion Yuan, 1.9 times more than that in 2005, among which state investment was 71 billion Yuan, an increase of 101.4 %.<sup>5</sup>

In 2009, there were 418 emergency accidents of environmental pollution and damage, of which 116 water pollution and damage accidents, 130 air pollution and damage accidents, and 55 solid waste pollution and damage accidents, 2 marine and 115 other pollution accidents. The direct economic loss of pollution accidents reached to 433.544 million Yuan. Based on the data in recent years (see Figs. 9.1 and 9.2), although China’s environmental pollution and damage accidents decreased distinctly, the caused direct economic loss remained at high level, which indicates that China’s environmental risk early warning and processing system is in urgent need to be improved to guarantee a better environmental safety.

At present, environmental pollution in China is still an important issue in economic development. Economy and environment can complement each other and interact with each other. Under certain natural and social circumstance, the rapid development of the economy can be affected by environmental conditions and have an impact on the environment in turn. Then the changed environment will react to the material production and development of human beings. Therefore, in a certain environment carrying capacity condition, the pursuits of green

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<sup>4</sup> National Bureau of Statistics, Series report No.1 of the development achievement for the “11th Five-Year Plan”: New Development, New Leaps and New Chapter”, March 1, 2011. [http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301\\_402706119.htm](http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301_402706119.htm)

<sup>5</sup> National Bureau of Statistics, Series report No.14 of the development achievement for the “11th Five-Year Plan”: Environmental protection has made positive progress”, March 10, 2011. [http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110310\\_402709535.htm](http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110310_402709535.htm).

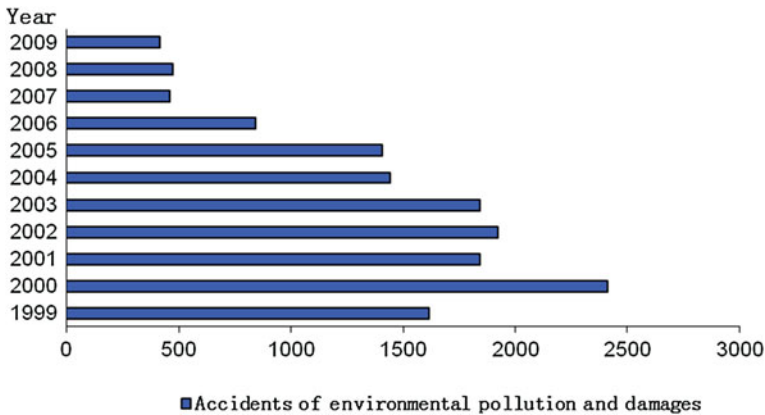
**Table 9.1** Annual investment in environmental pollution control

Index	Unit	2005	2006	2007	2008	2009
Total investment in environmental pollution control	100 million Yuan	2388.0	2566.0	3387.3	4490.3	4525.3
Investment in urban environmental infrastructure	100 million Yuan	1289.7	1314.9	1467.5	1801.0	2512.0
Investment in treatment of industrial pollution sources	100 million Yuan	458.2	483.9	552.4	542.6	442.6
Environmental protection investment under the “three simultaneous” regulation	100 million Yuan	640.1	767.2	1367.4	2146.7	1570.7
Environmental pollution control investment/GDP	%	1.30	1.22	1.36	1.49	1.33

Source National Bureau of Statistics, “‘11th Five-Year’ series of reports on economic and social development achievements No. 14: Environmental protection has made positive progress”, March 10, 2011

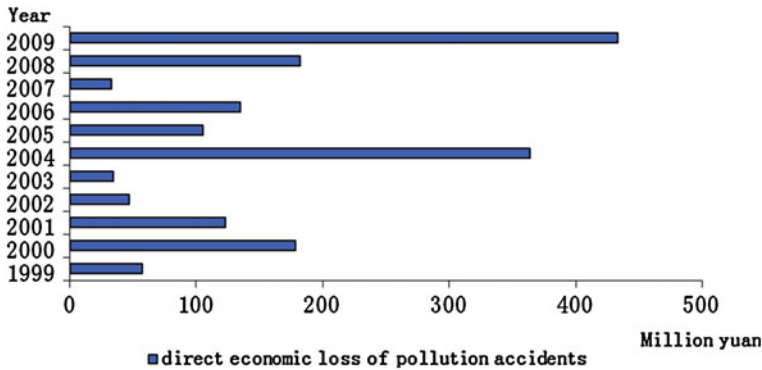
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Note “Three Simultaneous” means the pollution abatement infrastructure/facilities of a project must be “designed, constructed and operated” simultaneously together with main body of the project



**Fig. 9.1** Accidents of environmental pollution and damages in China (1999–2009). Sources National Bureau of statistics of China, “China Statistical Yearbook 2009”, Beijing: China Statistics Press, 2009; National Bureau of statistics of China, “China Statistical Yearbook 2010”, Beijing: China Statistics Press, 2010

development path, and efforts to reduce the pollutant emissions to improve environmental situation is of vital importance to promote sustainable economic and social development.



**Fig. 9.2** China’s direct economic loss of pollution accidents (1999–2009). *Sources* National Bureau of statistics of China, “China Statistical Yearbook 2009”, Beijing: China Statistics Press, 2009; National Bureau of statistics of China, “China Statistical Yearbook 2010”, Beijing: China Statistics Press, 2010

### 9.1.2 Pollutants Emission Reduction Progress

Since the “11th *Five-Year Plan* of National Economy and Social Development” put forward for the first time the targets of energy efficiency and environmental protection, energy saving and emission reduction has become a very important work for both the central and local governments. Governments at all levels attach great importance to this task, and set up a series of measures and policies to promote energy-saving and emission reduction work to be carried out smoothly. During the period of 11th *Five-Year Plan*, the main pollutants reduction had achieved remarkable effect, reflected by continue improvement for some environmental quality indicators (Table 9.2).

**Table 9.2** Main environmental control targets of the 11th Five-Year Plan

Indices	2005	2010	Changes during the 11th Five-Year (%)
Total chemical oxygen demand emissions (10,000 tons)	1414.2	1272.8	-10
Total sulfur dioxide emissions (10,000 tons)	2549.4	2294.4	-10
Proportion of the national controlled surface water quality monitoring sections with water quality worse than grade V	26.1	<22	-4.1
Proportion of the national controlled surface water quality monitoring sections with water quality better than grade III in seven major water systems	41	>43	2
Proportion of key cities having air quality better than Class II standard for over 292 days per year	69.4	75	5.6

*Source* Central government portal, “Notice of the State Council on issuing the 11th *Five-Year Plan* for national environment protection” [No. 37 (2007) of the State Council], [http://www.gov.cn/zwggk/2007-11/26/content\\_815498.htm](http://www.gov.cn/zwggk/2007-11/26/content_815498.htm)

During the 11th *Five-Year Plan* period, energy-saving and emission reduction have obtained unprecedented emphasis and made positive progress. In the meantime, the total discharge of pollutants became gradually under control; sulfur dioxide emission reduction targets was met 1 year ahead of schedule; chemical oxygen demand (COD) emission reduction target was achieved 6 month ahead of schedule. In 2010, the national COD emissions decreased by about 12 % compared with 2005 and sulfur dioxide dropped by 14 %, all of which exceeded the mandated emission reduction task in 11th *Five-Year Plan*. Furthermore, the effect of elimination of high emission and backward production capacity is outstanding. In the 11th *Five-Year Plan* period, China has eliminated backward iron production capacity of about 111.72 million tons, backward steel production capacity of about 66.83 million tons, backward coke production capacity of about 105.38 million tons, backward ferroalloy production capacity of about 6.63 million tons.<sup>6</sup>

### 9.1.2.1 Air Pollutant Emission Reduction

In the period of 11th *Five-Year*, the emissions of three kinds of main air pollutants, i.e. sulfur dioxide, soot and industrial dust all declined year after year. Up to 2009, sulfur dioxide, soot and industrial dust emissions decreased by 14.46, 22.19 and 35.23 % and their emissions were reduced respectively 3.74, 2.41 and 2.85 million tons. The effect of the major air pollutants emission reduction was significant (see Fig. 9.3).

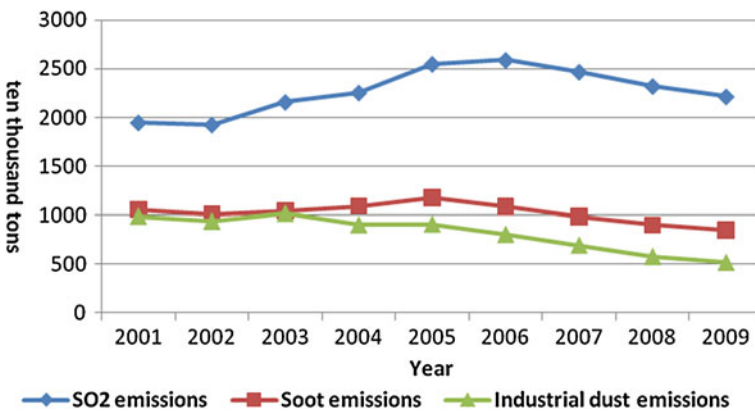


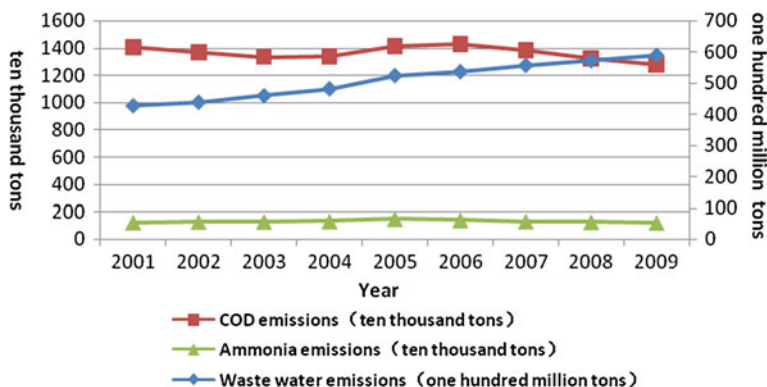
Fig. 9.3 Major air pollutants emissions. Source National Bureau of Statistics of China, “China Statistical Yearbook” (2002–2010), Beijing: China Statistics Press, 2002–2010

<sup>6</sup> National Bureau of Statistics, Series report No.1 of the development achievement for the “11th *Five-Year Plan*”: New Development, New Leaps and New Chapter”, March 1, 2011. [http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301\\_402706119.htm](http://www.stats.gov.cn/tjfx/ztfx/sywcj/t20110301_402706119.htm).

Specifically, in 2008, the national total emissions of sulfur dioxide were 23.21 million tons, decreased by 5.95 % than that of 2007; among them, industrial sulfur dioxide emissions fell by 6.95 % from the previous year, and domestic sulfur dioxide emissions rose slightly by 0.55 %. In 2009, the sulfur dioxide emissions continued to decline, with a gross discharge of 22.14 million tons, or a decrease of 4.6 % from the previous year. Compared with 2005, sulfur dioxide emissions fell by 13.14 %, and overfilled the 11th *Five-Year Plan* emission reduction targets of 10 %.

### 9.1.2.2 Reduction of Water Pollutants

In the period of 11th *Five-Year*, the amount of wastewater discharge showed an increasing trend year after year, but COD discharge was declining, and the emission reduction targets of 10 % has been achieved 6 months earlier. According to the latest “China Statistical Abstract 2010–2011”, in 2010, the national emissions of COD were 12.38 million tons, 12.45 % down compared with that of 2005, exceeding the emission reduction task. In addition, the ammonia emissions in the 11th *Five-Year* period did not change much in 2001–2009, showing the total emissions increased and then decreased in the trend (see Fig. 9.4).



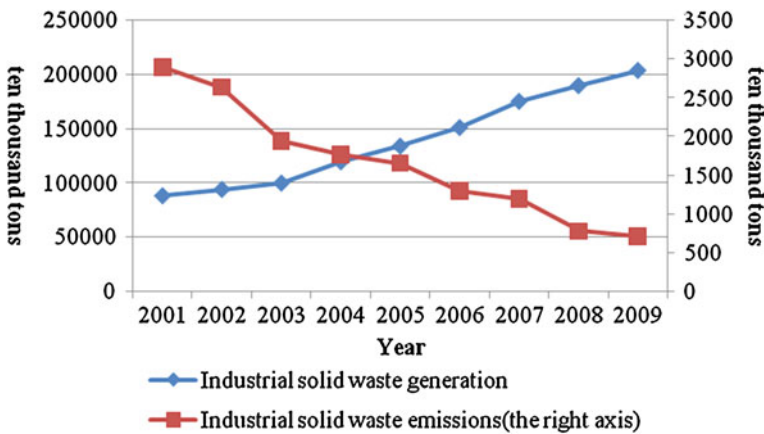
**Fig. 9.4** Annual waste water and water pollutants discharge. *Sources* National Bureau of Statistics of China, “China Statistical Yearbook” (2002–2010), Beijing: China Statistics Press, 2002–2010. Ministry of environmental protection, “Report on the state of the environment in China 2009”. <http://www.zhb.gov.cn/gzfw/xzxx/wdxz/201006/P020100603551633387739.pdf>

### 9.1.2.3 Solid Waste Reduction

In the period of 11th *Five-Year Plan*, China actively promoted the comprehensive treatment of solid waste, and “Solid waste pollution prevention information dissemination for national large and medium sized cities”. Meanwhile, China continued to promote the implementation of “Hazardous waste operating licensing

management approach”, and released the regulations of “Guideline for recording and reporting the operation conditions of the hazardous waste operating unit” “Guideline for hazardous waste management review and licensing” and “Regulations on Administration of Collection and Disposal of Waste Electrical Appliances and Electronic Products”. Additionally, strict waste import and export censorship system was set up and industrial solid waste conditions have been greatly improved.

In the period of 11th *Five-Year Plan*, the industrial solid waste generation grew year after year. In 2009, the amount of industrial solid waste was twice as that of 2001. In the same period, industrial solid waste treatment capacity (including utilization capacity, storage capacity and disposal capacity) continued to increase. Therefore, compared with the generation of the solid waste, discharges show the opposite trend. In 2009, discharges of industrial solid waste were less than one-third of that in 2001 (Fig. 9.5).



**Fig. 9.5** Annual solid waste generation and discharge. *Sources* National Bureau of Statistics of China, “China Statistical Yearbook” (2002–2010), Beijing: China Statistics Press, 2002–2010. Ministry of environmental protection, “Report on the state of the environment in China 2009”. <http://www.zhb.gov.cn/gzfw/xzzx/wdxx/201006/P020100603551633387739.pdf>

### Column 9.1 Multi-Actions on Emission Reduction Achieved Remarkable Improvement—Enshi City in Hubei Province

During the 11th *Five-Year Plan* period, focusing on the reduction of major pollutants emission and aiming at improving the quality of ecological environment, Enshi has achieved significant emission reduction effects through Effective actions of reducing emission, increasing environmental protection investment, adjusting industrial structure, accelerating management of emission reduction projects, etc.



(A) Emission reduction targets were set to show government's determination

According to the agreement signed by Enshi city government with the prefecture government, Enshi had reduced 1877.56 tons of chemical oxygen demand (COD) and 2362.65 tons of sulfur dioxide (SO<sub>2</sub>) during the 11th *Five-Year Plan* period. In the context of high economic growth, Enshi actively took actions such as speeding up elimination of backward production capacity, construction of key energy-saving and emission reduction projects, increasing investment in environmental protection, implementing energy-saving system, to ensure the completion of Five-Year emission reduction target.

To make sure the emission reduction being carried out smoothly, Enshi had published local governmental documents to regulate local polluter's behavior, such as, 'Notice of Reduction Task of Total Amount of Major Pollutants', 'Notice of Time Limit for Environmental Treatment', 'The Provision of Environmental Treatment Projects and Environmental Protection Objectives Assessment and Reward for the Townships and sub-district Offices'. Meanwhile, the Enshi government allocated the task of emission reduction to specific enterprises, townships, and sub-district offices, in the form of signing responsible agreement of environment protection objectives. With environmental objectives assessment and strict supervision, the pollution reduction responsibilities could be ensured. Those who failed to meet the requirement within the time limit, would be given a veto, meaning that the leaders could be removed from their position.

(B) Strict environmental pollution source control

During the 11th *Five-Year Plan* period, Enshi enhanced environmental supervision, and shut down heavily polluting plants which could not meet the industrial policies and the environmental standard requirements. Those plants are as follows: 3 cement companies (Enshi Xintang Cement Company, Enshi Lianzhu Cement Co., Ltd. and Fumin Cement Co., Ltd.), a paper-making enterprise (Enshi Dongchang Paper-making Enterprise), and a chemical company (Enshi Balong Fertilizer Co., Ltd.). Just through those shutting down, Enshi achieved an annual reduction of 129.21 tons of COD and 92.52 tons of SO<sub>2</sub>. In 2008, Qiyangba Power Plant was cut off, resulting in more than 1,000 tons reduction of SO<sub>2</sub> per year.

Meanwhile, Enshi took strict examination procedure to prevent new pollution sources. The newly built, rebuilt and expanded projects must strictly comply with 'Law of the People's Republic of China on Appraising of Environment Impacts', 'Law of the People's Republic of China on Appraising of Environment Impacts' and other laws or regulations as well as national industrial policies, and strictly abide by environmental function zoning, environmental quality objectives and total quantity control of pollutant requirements. The "threshold" of new construction projects was effectively raised.

(C) Supporting enterprises to construct pollution abatement projects

Because of technical and economical difficulties, Enshi Jiuzhou Livestock Co. was in lack of sewage treatment facility, and could not meet waste water

discharging quality substandard. Enshi government actively sought the funding support with 600,000 Yuan from the 'national special environmental pollution control funds', to build a new sewage treatment facility. During the period of 2008–2009, the government raised more funding support to a new high-standard sewage treatment plant in Cuiba meat processing base, with treatment capacity of 700 tons per day using advanced UASB anaerobic wastewater treatment technology. The waste water discharged through the treatment can meet standard A of 'meat processing industry effluent discharge standards(GB13457-92)'.

With the strong support of Enshi government, Enshi Shanzhai Leather Co., Ltd., Hubei Jinhua Paper Co., Ltd., Hubei Shengfeng Pharmaceutical Co., Ltd., Hubei Chengcheng Pharmaceutical Co., Ltd., also managed to get help from 'national special environmental pollution control funds', with a total amount of 10 million Yuan. After these five companies' sewage treatment projects being constructed, the total sewage treatment capacity will reach 4,000 tons per day, so as to reduce 94 tons of COD per year.

#### (D) Sewage pipeline network construction

Enshi Shouchuang Water Co., Ltd, which lies in the downstream of Qingjiang river, can treat nearly 60,000 tons of domestic sewage per day, with its discharged water achieving emission standard B. Since the plant was put into trial operation, a sewage pipeline network of 35 km and more than 300 sewage outlets have been constructed to collect and transport urban sewage to the waste water treatment plant. During the 11th *Five-Year Plan* period, Enshi has spent 54.74 million Yuan on the construction of sewage pipe network. With the continuous extension and connection of the sewage pipe network, there will be more areas that could be accessed by sewage network during the 12th *Five-Year Plan* period, which will further improve water environmental quality in Enshi City.

Source: Enshi environmental protection bureau website  
<http://www.eshbj.com.cn/news/huanbaoxinwen/2010/1214/101214169323FG3F8F271AE1C434KK2.shtml>.

### ***9.1.3 Relationship Between Pollution and Economic Development***

In this section, we will take use of the indicator, "Pollution-Economy Time Elasticity (PETE)", i.e. the ratio of annual growth rate (%) of the emissions of major pollutants over the annual growth rate (%) of China's economic growth, to discuss the relationship between the pollution and the economic development for the nation and the different regions.<sup>7</sup> The major pollutants indicators and economic

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<sup>7</sup> MAO Xianqiang, YANG Shuqian. The Concept, Method and Application of the Pollution-Economy Time Elasticity (PETE) [J]. China Population, Resource and Environment, 2010(11), 156–160.

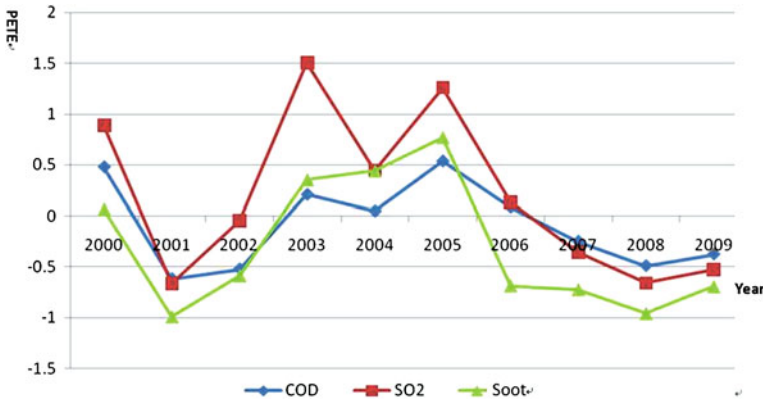


Fig. 9.6 Fluctuation of PETE of pollutant emissions in China (2000–2009)

indicators in 2000–2009 are employed to explore the variation of China’s environmental loads in the periods of 10th *Five-year* and 11th *Five-Year*.

Considering the degree of social concern and data availability, in this section, chemical oxygen demand (COD), sulfur dioxide (SO<sub>2</sub>) and soot are selected as the main pollutants indicators; and gross domestic product (GDP) as the economic indicator using the 1990 comparable price. The data used comes from “China Statistical Yearbook”, “China Environment Yearbook” and “Compilation of Statistics for New China’s 50 Years” and other information.

In 2000–2009, the total emission of COD, SO<sub>2</sub> and soot in China showed similar fluctuation characteristics (see Fig. 9.6).

Since 2000, China’s GDP and industrial output value of enterprises has maintained growth trend, therefore, positive PETE means simultaneous growth of pollution and economy while negative PETE indicates an emission reduction over the previous year.

From Fig. 9.6, in the 10th *Five-Year Plan* period, PETE of the three pollutants fluctuated significantly. The values in 2001 and 2002 are negative, indicating a relative pollutant emissions reduction compared with the previous year, and the economic growth is relatively clean. The values in remaining years are positive, which indicates that the pollutant emissions increase along with the expansion of the economic scale year after year. In 2003 and 2005, the PETE of SO<sub>2</sub> is greater than 1, which means the rate of the emission increase is higher than the GDP growth rate, and the economic growth pattern is relatively “dirty”. In that case, economic development pays bigger environmental cost and the environment bears larger pressure.

Since 2006, the PETE values of the three pollutants significantly decreased in different degree and turned negative in 2006 and 2007, while GDP has increased annually. This shows that, different from the 10th *Five-Year Plan* period, in the 11th *Five-Year Plan* period, the development direction of pollution and economy is opposite. Economy became “cleaner” and “clean and efficient” industries are

replacing “dirty and inefficient” industries; or “economic output increase makes increased investment in pollution control with remarkable results”. It is noticeable that, the PETE value has increased in 2009 over 2008, although still negative. It reminds that the emission reduction could be more difficult in the post 11th *Five-Year Plan* period.

## **9.2 Regional Comparison of Environmental Carrying in China’s Green Economic Development in the 11th Five-Year Plan Period**

To reflect the spatial differences and variation trends in environmental carrying in the process of China’s economic development during 11th *Five-Year Plan* period, the relationship between pollution reduction and economic development has been analyzed at regional level.

### ***9.2.1 Comparison of Regional Emission Reduction Progress***

According to “Several Opinions of the Central Committee of the Communist Party of China (CCCPC) and the State Council on Boosting the Rise of the Central Region,” “Directive by the State Council on the policies and measures of Western Development “and the spirit of the 16th Party Congress report, in order to scientifically reflect the regional difference in socio-economic development, and to provide the basis for regional development policy making by the central government, China has been divided into four economic regions, i.e. eastern, central, western and north-east regions. Eastern region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. Central region includes Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. Western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. Northeast region includes Liaoning, Jilin and Heilongjiang. Based on these four regions, in this section, we shall analyze the progress of Chinese emissions reduction and PETE indicator through regional comparison.

#### **9.2.1.1 Comparison of Air Pollution Reduction**

During 11th *Five-Year* period, China’s three major air pollutants emission, i.e. sulfur dioxide, soot and industrial dust, decreased year by year.

Compared with 2005, total sulfur dioxide emission rate of the eastern region reached 19.02 % in 2009, 13.14 % higher than the national average. Shandong, Jiangsu and Hebei provinces ranked the top three in the eastern region. In the same

**Table 9.3** Annual and cumulative air pollutants reduction rates by region (Unit %)

Sulfur dioxide emissions reduction rate						
	2005–2006 (%)	2006–2007 (%)	2007–2008 (%)	2008–2009 (%)	Cumulative reduction rate (2009 over 2005) (%)	
National	-1.55	4.66	5.95	4.60	13.14	
East	1.29	5.63	7.53	6.00	19.02	
Northeast	-4.74	1.73	6.22	5.45	8.73	
Central	-0.89	4.30	6.01	4.21	13.08	
West	-3.69	4.51	4.44	3.45	8.65	
Soot reduction rate						
	2005–2006 (%)	2006–2007 (%)	2007–2008 (%)	2008–2009 (%)	Cumulative reduction rate (2009 over 2005) (%)	
National	7.95	9.36	8.62	5.99	28.32	
East	2.89	12.80	3.91	4.63	22.40	
Northeast	2.17	2.82	5.38	6.85	16.21	
Central	7.71	11.44	13.59	8.17	35.14	
West	14.16	7.96	9.24	4.68	31.64	
Industrial dust reduction rate						
	2005–2006 (%)	2006–2007 (%)	2007–2008 (%)	2008–2009 (%)	Cumulative reduction rate (2009 over 2005) (%)	
National	11.28	13.56	16.29	10.48	42.53	
East	11.28	11.50	12.26	17.53	43.18	
Northeast	5.74	3.61	29.79	13.49	44.81	
Central	8.89	14.17	17.80	7.02	40.23	
West	15.47	17.35	13.47	7.57	44.12	

Source: National Bureau of Statistics of China, "China Statistical Yearbook" (2002–2010), Beijing: China Statistics Press, 2002–2010

period, cumulative reduction rate in the western region was the lowest, only 66 % of the national average.

Regionally, the cumulative emission reductions of soot in the western and central regions were much higher than that in the east and northeast and the national average.

Cumulative emissions reduction of industrial dust of all regions decreased more significantly compared SO<sub>2</sub> and soot. The cumulative reduction rates in the eastern, northeastern and western regions from 2005 to 2009 were higher than the national average (Table 9.3).

### 9.2.1.2 Comparison of Water Pollution Reduction

During the 11th *Five-Year Plan* period, national waste water discharge showed increasing trend year by year, but the chemical oxygen demand emissions declined and achieved 10 % reduction target 6 months in advance. Regionally, from 2005 to 2009, cumulative emission reduction rate of chemical oxygen demand in the eastern emission reached 13.52 %, higher than the national average level of 9.66 %. For the same period, cumulative emission reduction rate of chemical oxygen demand in the western region was the lowest, only 63 % of the national average (Table 9.4).

The changes in ammonia emissions for different regions showed a declination year by year during 2006–2009. Ammonia emissions in the western region in 2008 showed an increase of 0.78 % compared with the previous year, following 2 years' consecutive decrease. While ammonia emissions in the eastern, northeastern and central regions achieved continuously decrease.

### 9.2.1.3 Comparison of Solid Waste Reduction

During 2001–2009, the amount of industrial solid waste generation increased year by year and was over twice of that in 2001. During this period the country's industrial solid waste treatment capacity (including capacity utilization, storage capacity and disposal capacity) continued to increase. Therefore, compared to industrial solid waste generation, solid waste emissions show an opposite trend. In 2009, emissions of industrial solid waste were less than one-third of that in 2001.

For the industrial solid waste emission reductions, in 2009, the top ten provinces and municipalities are: Shanxi, Hebei, Inner Mongolia, Hunan, Shaanxi, Sichuan, Ningxia, Henan, Zhejiang and Hubei. For the same period, industrial solid waste emissions in Chongqing, Shanxi and Xinjiang were more than 1million tons, 1.4986, 1.4157 and 1.052 million tons respectively.

For domestic solid waste, the municipal solid waste generation, waste treatment and disposal capacity, living garbage harmless treatment rate and processing capacity all increased during the 11th *Five-Year Plan* period.

Regionally, in 2009, garbage harmless treatment rate have significantly increased compared with 2008 both in overall level and provincial level. The top ten provinces are: Beijing, Zhejiang, Chongqing, Tianjin, Fujian, Jiangsu, Shandong, Guangxi,

**Table 9.4** Annual and cumulative water pollutants reduction rates by region (Unit: %)

COD reduction rate						
	2005-2006 (%)	2006-2007 (%)	2007-2008 (%)	2008-2009 (%)	Cumulative reduction rate (2009 over 2005) (%)	
National	-0.99	3.25	4.42	3.27	9.66	
East	0.75	3.64	5.44	4.37	13.52	
Northeast	-0.06	2.58	5.36	3.42	10.90	
Central	-1.92	2.62	3.86	3.10	7.54	
West	-2.51	3.31	3.30	2.02	6.08	
NH <sub>3</sub> -N reduction rate						
	2005-2006 (%)	2006-2007 (%)	2007-2008 (%)	2008-2009 (%)	Cumulative reduction rate (2009 over 2005) (%)	
National	5.64	6.36	4.06	3.44	18.14	
East	4.23	3.87	4.24	5.80	16.95	
Northeast	10.33	7.74	3.77	4.04	23.60	
Central	1.67	5.04	7.76	2.62	16.13	
West	9.69	10.93	-0.78	0.53	19.36	

Source: National Bureau of Statistics of China, "China Statistical Yearbook" (2002-2010), Beijing: China Statistics Press, 2002-2010

Jiangxi and Sichuan. Among these 10 provinces, harmless treatment rates of 7 provinces were higher than 90 % and the others were higher than 83 %. In comparison, the national average rate was 71.39 %.

## 9.2.2 Regional Comparison of PETE Index

### 9.2.2.1 Air Pollution Elasticity

Sub-regional PETE for air pollution is detailed in Table 9.5.

**Table 9.5** Comparison of regional PETE indices for air pollutants in 2006–2009

Sulfur dioxide				
	2006	2007	2008	2009
National	0.13	−0.36	−0.66	−0.53
East	−0.10	−0.40	−0.78	−0.66
Northeast	0.37	−0.12	−0.65	−0.60
Central	0.07	−0.30	−0.63	−0.46
West	0.29	−0.32	−0.46	−0.38
Soot				
	2006	2007	2008	2009
National	−0.69	−0.72	−0.96	−0.69
East	−0.23	−0.90	−0.41	−0.51
Northeast	−0.17	−0.20	−0.56	−0.75
Central	−0.61	−0.81	−1.42	−0.90
West	−1.11	−0.56	−0.96	−0.51
Industrial dust				
	2006	2007	2008	2009
National	−0.89	−0.96	−1.70	−1.15
East	−0.89	−0.81	−1.28	−1.93
Northeast	−0.45	−0.25	−3.10	−1.48
Central	−0.70	−1.00	−1.85	−0.77
West	−1.22	−1.22	−1.40	−0.83

#### Notes

1. In the calculation of the pollutant emission—economic time elasticity (PETE) in this form, we use the 2000 constant GDP in WDI database in World Bank
2. Data for pollutants comes from “China Statistic Yearbook 2006–2010”
3. Pollutant emissions-economic time elasticity is calculated as the ratio of annual emissions increase rate over annual GDP increase rate
4. In 2006–2009, China’s economy has maintained rapid growth. So when pollution increases, PETE is positive, and the smaller the PETE, the less pollution cost of the country (or region, industry) to increase its GDP (or regional GDP, added value) is. PETE less than 1 indicates environmental deterioration rate less than the rate of economic growth; while PETE value greater than 1 indicates that the pollution increases at a rate higher than the rate of economic growth. When the PETE is negative, it is indicated that pollutant emission is reducing along with economic growth and the economic development is in a “clean” track



Regionally, in 2006 the PETE of sulfur dioxide emissions in the eastern region was negative, and those of the northeast, central and western regions were positive, i.e. 0.37, 0.07 and 0.29 respectively. Since 2007, along with rapid economic development, total sulfur dioxide emissions in the east, northeast, central and western regions have declined and PETE indices of sulfur dioxide were negative. In 2007, sulfur dioxide emissions reduction in eastern were better than the national average, western followed, while northeastern and central regions have same reduction. In 2008 and 2009, PETE indices of sulfur dioxide continued to decrease, and those of eastern and northeastern regions in two consecutive years were higher than national average, followed by the central and western. Especially, after achieving higher level of economic development, eastern region began to actively adjust the industrial structure, to develop cleaner industries, to increase investment in environmental governance, so as to achieve positive improvement of environmental quality.

During the 11th *Five-Year Plan* period, soot and industrial dust emissions maintained a constant decline trend, leading to consecutive negative PETE indices for both the country and each region from 2006 to 2009, indicating a “win-win” pattern of the emissions reduction along with economic growth.

### 9.2.2.2 Water Pollution Elasticity

During the 11th *Five-Year Plan* period, China had newly built a batch of wastewater treatment projects, as a result, the urban sewage treatment capacity of the country has been greatly improved. Although the quantity of industrial wastewater and domestic sewage increased, COD and ammonia emissions decreased year by year and water environment was also improved significantly (Table 9.6).

**Table 9.6** Comparison of regional PETE indices for water pollutants (2006–2009)

COD				
	2006	2007	2008	2009
National	0.09	-0.25	-0.49	-0.38
East	-0.06	-0.26	-0.57	-0.48
Northeast	0.01	-0.18	-0.56	-0.38
Central	0.15	-0.18	-0.40	-0.34
West	0.20	-0.23	-0.34	-0.22
NH <sub>3</sub> -N				
	2006	2007	2008	2009
National	-0.44	-0.45	-0.42	-0.38
East	-0.33	-0.27	-0.44	-0.64
Northeast	-0.81	-0.55	-0.39	-0.44
Central	-0.13	-0.35	-0.81	-0.29
West	-0.76	-0.77	0.08	-0.06

Note the same as Table 9.5

In 2006, the national PETE of COD emission was positive, and only in the eastern region the emissions of COD decreased along with economic development, while those in the northeast, central and western regions were increasing.

From 2007 to 2009, the PETE indices of national and the regional emissions of COD were all negative, showing the significant effects of regional COD emission reduction efforts.

PETE indices of  $\text{NH}_3\text{-N}$  in 2006–2009 kept negative value. In 2006 and 2007,  $\text{NH}_3\text{-N}$  emission reduction efforts in the northeast and western regions took better effects than the national average. In 2008, PETE indices of  $\text{NH}_3\text{-N}$  changed from negative to positive. In 2009, total  $\text{NH}_3\text{-N}$  emission reduction effect in the western region was not as obvious as other regions. In general, water pollution situation has been significantly improved along with the national and local economic development.

### 9.2.2.3 Solid Waste Emissions Elasticity

During the 11th *Five-Year Plan* period, the PETE indices of industrial solid waste for the nation and the regional mostly showed negative value. Exceptionally, in some year and in some regions, PETE indices showed positive values, e.g., northeast region in 2006 and 2009, east region in 2008, west region in 2009.

In comparison, PETE indices of municipal solid waste (MSW) were all negative in 2006, but showed positive values for the national average and the east and west regions in 2007–2009. This indicates that MSW could be a more challenging problem in the coming years (Table 9.7).

**Table 9.7** Comparison of regional PETE indices for solid waste in 2006–2009

Industrial solid waste				
	2006	2007	2008	2009
National	-1.68	-0.57	-3.61	-1.00
East	-1.25	-1.04	4.14	-3.92
Northeast	11.50	-5.57	-5.11	6.21
Central	-2.21	-0.47	-4.09	-3.96
West	-1.46	-0.40	-3.89	1.46
Municipal solid waste				
	2006	2007	2008	2009
National	-0.27	0.07	0.16	0.21
East	-0.01	0.52	0.31	0.39
Northeast	-0.37	-0.23	-0.21	-0.06
Central	-0.89	-0.3	0.2	-0.02
West	-0.12	0.1	0.01	0.26

*Note* Municipal solid waste emission is calculated through dividing “municipal solid waste harmless treatment quantity” by “municipal solid waste harmless treatment rate”

## Column 9.2 The Harvest of Harmonious Accomplishment of both Material Wealth and Environmental Wealth—Beilun district, Ningbo City, Zhejiang Province

Due to the unique advantages of the port, six port industries including petrochemical, energy, steel, paper, automobiles and ships, have been well developed in Beilun District. Beilun port now is becoming an important industrial base in Zhejiang province with the largest scale and the densest industries. During the 11th *Five-Year Plan* period, the regional economy in Beilun district has expanded by 134 % and container throughput has increased by 200 %. However, with the economic expansion, massive land occupation, water and energy consumption (coal consumption in Beilun district increased by 50 % during the 11th *Five-Year Plan* period), as well as large amounts of “three wastes” emissions, have threatened severely the environmental carrying capacity.

Although being confronted with such a tremendous environmental pressure of regional development, Beilun took the lead in passing through the “811” environment renovation examination in the province. Through a series of projects of environmental treatment, pollution reduction, environmental supervision and wisdom environmental protection, COD and SO<sub>2</sub> were cut by 53 and 76 % in total, energy consumption per unit of GDP dropped by 23.8 %. The daily wastewater treatment capacity in the region has reached 420,000 tons and sewerage networks has expanded up to 329 km long, ranking the top in Ningbo, and achieving emission reduction target of 11th *Five-Year Plan* ahead of schedule. The production capacity of reclaimed water per day has amounted to 125,000 tons, which also ranks front row in the country. Beilun has constructed 210 km of clean water streams, and kept the drinking water sources’ quality compliance rate at 100 %.

The “Forest Beilun” program has brought the green coverage rate of built-up areas up to 38.5 %, and the public green area per capita to 13.5 m<sup>2</sup>, with a growth rate of 2.7 and 3.7 % compared with 2005 respectively. The proportion of class A air quality days in the five consecutive years has been kept above 90 %.

All these achievement enables Beilun being named as National Environmental Protection Model City and State-level ISO14000 Model District.

### (A) Strengthened financial inputs into environmental treatment

Beilun district has successively invested 2.6 billion Yuan into completing 54 projects of industrial waste gas abatement, sewage pipeline network construction, and special pollution treatment projects for electroplating factories, printing factories, coal-fired boilers and foundries, to promote environmental management into “fast track”.

### (B) Emission Reduction

During the 11th *Five-Year Plan* Period, MEP (Ministry of Environmental Protection) had checked and ratified that Beilun had reduced COD and SO<sub>2</sub> emissions 5,421 tons and 95,982 tons respectively, with reduction rates of 18.21 and 47.65 % of total quantities. Beilun had been commended as National Emission Reduction Advanced Model in 2007 and 2009.

### (C) Environmental Supervision

Beilun has enforced supervision and monitoring to key enterprises. A long-term integrated supervision and monitoring system of all-weather, full-time, comprehensive and multi-level, has been constructed. Special environmental protection programs, such as “Clear Water”, “Environmental Safety”, “Blue Sky” and “Ease of Radiation”, were conducted to seek immediate effects. These experiences were reported on the front page of ‘China Environmental News’.

### (D) Smart Environmental Protection

To further enhance environmental governance capability, Beilun employed a “Smart Environmental Protection” project, to strengthen environmental information management focusing on basic data collection, monitoring and pre-warning, to achieve information integration and quantitative management for environment.

Source: Zhejiang environmental protection bureau website  
[http://www.zjepb.gov.cn/root14/auto506/201104/t20110419\\_95431.html](http://www.zjepb.gov.cn/root14/auto506/201104/t20110419_95431.html).

## **9.3 The Prospect of the Environmental Carrying in China’s Green Economic Development in the 12th Five-Year Plan Period**

12th *Five-Year Plan* period is a critical period to open up the future and continue to implement the scientific development concept, and to vigorously develop green economy. Looking ahead, continuous efforts to promote pollution reduction, is still a crucial challenge to face. Through creative co-control mechanism to achieve multi-pollutants emission reduction is an important way to green development.

### ***9.3.1 Multi-pollutants Emission Reduction Targets***

In the 2009 UN General Assembly, President Hu Jintao promised to the world that, by 2020, China’s carbon dioxide emissions per unit of GDP will be decreased by 40–45 % compared with 2005 and the share of renewable energy will be increased to about 15 %.<sup>8</sup> During Climate Change Conference in Copenhagen at the end of 2009, Premier Wen Jiabao further pledged to bring emission reduction targets as binding targets into long-term economic and social development planning, and to ensure its implementation receiving legal and public supervision. Government work report 2011 and the 12th *Five-Year Plan* established emission reduction

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<sup>8</sup> See the press conference of the Fourth Session of Eleventh National People’s Congress. <http://gb.cri.cn/1321/2011/03/06/661s3174141.htm>.

targets during the period 2011–2015: the ratio of non-fossil fuels in primary energy consumption being increased to 11.4 %, energy consumption and carbon dioxide emissions per unit of GDP being reduced by 16 and 17 % respectively, and the total discharge of major pollutants being decreased by 8–10 %, forest volume being increased by 6 billion cubic meters, with the forest coverage rate reaching 21.66 %.

After the release of 12th *Five-Year Plan* during the two conferences (i.e., the National People’s Congress and the Chinese People’s Political Consultative Conference) which proposed the binding control targets requirements to reduce the four major pollutants, the Ministry of Environmental Protection announced the 12th *Five-Year Plan* emissions reduction targets, i.e. sulfur dioxide and chemical oxygen demand emissions being decreased by 8 % compared with 2010, ammonia, nitrogen oxides emissions being reduced by 10 % (detailed in Table 9.8).

**Table 9.8** Emission reduction targets during the 12th Five-Year Plan period

Indicator	Target
The ratio of Non-fossil fuels in primary energy consumption	Increase to 11.4 %
Energy consumption per unit of GDP	16 % reduction
CO <sub>2</sub> emissions per unit of GDP	17 % reduction
COD emissions	8 % reduction
SO <sub>2</sub> emissions	8 % reduction
Ammonia emissions	10 % reduction
NO <sub>x</sub> emissions	10 % reduction
Forest volume	Increased by 6 billion cubic meters
Forest coverage rate	Reaching 21.66 %

Source Xinhua Net. The 12th “Five-Year Plan” of National Economic and Social Development of P. R. China

[http://news.xinhuanet.com/politics/2011-03/16/c\\_121193916.htm](http://news.xinhuanet.com/politics/2011-03/16/c_121193916.htm)

### Column 9.3 Strengthening Circular Economy and Developing Green Industry—Miluo City, Hunan Province

In recent years, Miluo, a famous historical city, has developed its circular economy and fostered its green industry to step up to a resource-saving and eco-friendly way of development.

#### (A) Uprising industry developed from waste picking tradition

As early as the end of Qing dynasty, residents of Miluo began to pick up second-hand goods. To the 1990s, a 6 km recycling corridor had been formed from Xinshi town to Miluo city along the road. In recent years, Miluo City Committee and Government has successively invested 50 million Yuan into building Mid-South Renewable Resource Market which covers 50,000 m<sup>2</sup>. The booming renewable resource industries have brought Miluo tremendous economic and social benefits. By 2010, the renewable resource industry has formed nearly 8,000 private entrepreneurs with assets over one million Yuan in Miluo, and created 120,000 job opportunities, and brought about wage income over 450 million Yuan.

In August 2010, the National Development and Reform Commission (NDRC), Ministry of Finance (MOF) jointly issued a special article to explicitly list Miluo's circular economy industrial park as one of first batch of seven "urban mining" demonstration bases. Miluo is facing an unprecedented development chance of circular economy.

(B) Inexhaustible "mine" created by green development

With numerous wastes streamed in from everywhere, there could be "secondary pollution" if those wastes are not properly handled. Therefore, Miluo set green development as the supreme concept. Through combining the development of renewable resource industry and environmental protection closely, Miluo finally explored a circular economy development way of "integrating the mine into the city". In 2010, Miluo reclaimed over 1.45 million tons of recycling waste materials from all over the country to produce 560,000 tons of recycled copper and aluminum. Miluo has become the country's major renewable material supply base of reclaimed copper, aluminum, stainless steel, plastic etc., which is equivalent to build a renewable mine worth of over 100 billion Yuan for each year.

(C) "Two-Orientation (resource-conserving and environment-friendly) Society" construction experiences explored

In October 2005, Miluo's market for renewable resources was listed in the first batch of national circular economy pilot scheme. In the past 5 years, Miluo conducted effective exploration using the opportunities and favorable national policies. The valuable experiences drawn for building "resource-conserving and environment-friendly society" are as follows:

1. Sound market systems and resource collection-distribution networks. Relying on the Mid-South Renewable Resource Market, Miluo gradually built three new networks, namely, renewable resource recycling network, logistic distribution network and electronic trading network, and three new markets, namely renewable resources market, renewable raw materials market and recycled product market. Currently, Miluo has 206 renewable resource recycling companies, more than 3,550 operating households and over 5,100 purchasing outlets distributed throughout the Country.
2. Solid industrial park platform and concentrated resources use. Miluo's circular economy industrial park has forged five processing sections of recycled copper, aluminum, steel, plastics and rubber, and there are 247 renewable resources processing companies with a total processing capacity of 500,000 tons per year.
3. Innovation and business development of high technology. By integrating production, education and research sectors, Miluo has constantly guided enterprises to upgrade technologies, so as to maximize utilization and productivity of renewable resources. For example, the oxygen-free copper rods of Xiangbei Copper Co, Ltd, and the recycled aluminum production technology of Zhongtian Aluminum Co, Ltd., have become the leading technologies in the country.

4. Standardized industry management. Renewable resources industry association, accounting-consulting company, asset management company, and SME credit guarantee company have been built up to form a suitable platform for enterprises' grown up.

(D) To build demonstration brand by optimization and upgrading

During the 12th *Five-Year Plan* period, with the aim of building Mid-South's largest and most influential "urban mining" pilot base, Miluo will take great efforts to promote "upgrading and improvement".

1. To upgrade and improve infrastructure. Miluo will invest about 2 billion Yuan to upgrade the industrial park road network, energy system, water system, fire-fighting, sanitation, and to build resettlement for residents so as to enhance the park's carrying capacity;
2. To upgrade and improve the environmental protection facilities. Wastewater collection pipe network, wastewater deep treatment plant, water reuse pipeline network, centralized industrial solid waste disposal center and other environmental projects will be constructed with investment of 700 million Yuan;
3. To upgrade and improve the recycling network. With Mid-South Renewable Resources Market and convenient transportation, professional recycling companies will be developed to expand its renewable resources reclamation capacity up to 4 million tons per year.
4. To upgrade and improve the industrial chains. 32 key industrial upgrading projects related to processing waste copper, aluminum, stainless steel, plastic and rubber, will be constructed to reach an annual renewable resources processing capacity of 2.4 million tons in 5 years.

Through 5 years' efforts, an "urban mining" pilot base with characteristics of advanced technology, standardization management and beautiful environment, will be constructed to promote resource recycling industries and finally to make new contributions to the construction of "resource-conserving and environment-friendly society".

### ***9.3.2 Innovative Emission Reduction Mechanism: Co-Control***

Reviewing the development of the 11th *Five-Year Plan* period, environmental protection and energy saving have been paid unprecedented attention, and made great progress.

However, emission reduction situation will be still severe during the 12th *Five-Year Plan* period. Compared with the 11th *Five-Year Plan* emission reduction targets, 12th *Five-Year Plan* period pays more attention to a comprehensive energy saving and emission reduction. Among them, two more pollutants were added to the list of pollutants emission reduction targets, i.e. the total ammonia nitrogen emission being reduced by 10 %, and the total nitrogen oxides emission being

reduced by 10 %, by 2015. As the same time, the target for energy consumption per unit GDP during 12th *Five-Year Plan* period should be 16 % less and carbon dioxide emissions per unit of GDP should be reduced by 17 % by 2015. All these require more comprehensive thinking of using co-control measures to achieve multi-target.

Energy saving during 11th *Five-Year Plan* period mainly focused on pollution emission reduction and decrease of energy consumption per unit of GDP, but missed the synergistic reduction effect of various air pollutants and greenhouse gases. For example, environmental protection department only concentrated on the local air pollutant control target but not energy saving and CO<sub>2</sub> emission control, pollution emission management mainly focused on end-of-pipe control which is often at the cost of increased energy consumption and CO<sub>2</sub> emission. Also, when considering a variety of pollution control targets, end-of-pipe control measures or policies are not necessarily the most cost-effective optimization.

The challenging energy saving tasks of the 12th *Five-Year Plan* is calling on an urgent need for the co-control of both local and global pollutants and energy consumption.

In order to achieve the co-control effect of reducing emissions both for major air pollutants and greenhouse gases simultaneously, more measures of front-end-control and in-the-process control should be taken. As in the energy and industrial activities, SO<sub>2</sub>, NO<sub>x</sub> and other air pollutants and greenhouse gas emissions are mostly generated from the burning of fossil energy, there is a considerable potential for co-control.

Co-control does not control a certain air pollutant or greenhouse gas, but apply the idea of integrated control in order to obtain maximum overall efficiency. Specifically, for a number of existing air pollutants and greenhouse gases, co-control means to choose and combine all those control measures from the source control, to the production process control, and to the end-of-pipe treatment (including virtual alternative control measures, macroeconomic policy measures, etc.), with the least unit emission reduction cost.

During the 12th *Five-Year Plan* period, there are three ways to implement co-control strategy for the major air pollutants and greenhouse gas emissions reduction based on the integrated consideration of efficiency effect, structural effect and scale effect:

1. To improve efficiency. Through strengthening management and technical progress, the efficiency of each links of the production chain and pollution abatement measures should be improved. Meanwhile, the emissions of carbon, sulfur, nitrogen and other pollutants per unit output will decrease. At the micro level, promoting efficiency means transforming from high-carbon, high-polluting production processes (or pollution abatement measures) to low-carbon and low-pollution production process, changing from the end-of-pipe control measures to the front-end and in-the-process control measures, to reduce energy consumption per unit output and pollutant emissions in various industry sectors.



2. Industrial restructuring. China will promote the adjustment of industrial and energy structure, and promote economic resources to be reallocated from high-carbon, high-polluting sectors and products to low-carbon, low-pollution sectors and products, and from energy-intensive industries to technology-intensive industries and services.
3. Optimization of production scale. Through economic development scale optimization and economic growth rate control, an acceptable rate of the discharge of pollutants will be achieved. Though China is still in the period of rapid economic development and development is still top priority, in order to coordinate the economic development and environment protection, keeping a moderate economic growth rate is still an effective optional strategy.