THE CHINESE ENVIRONMENTAL POLICY RESEARCH WORKING PAPER

Issue 17   Volume 5   No.2   March 2018

CAEP Chinese Academy for Environmental Planning
http://www.caep.org.cn

Indicators-based Environmental Performance Assessment for China's Total Emission Reduction Policy during the 11th Five Year Plan

YANG Weishan, CAO Dong, ZHAO Xuetao

Foreword »

Editor in Chief: Prof. WANG Jinnan

Since its opening-up and reform, China has been in the process of rapid economic development with its people enjoying an increasingly improved standard of life. Meanwhile accompanying this dramatic economic growth is the degradation of environment which has, to some extent, damaged the gains of the opening-up and reform and prevented the economy from a healthy and sustainable development. The Chinese government is increasingly aware of that without addressing the environmental issues it is facing now, will jeopardize its long term goal of the great rejuvenation of the Chinese nation. Given the magnitude and complexity of the environmental issues in China, there is no easy way in addressing them and the solution to them entails an equal priority being given to environmental protection, ecological conservation and economic development or even higher than the latter by mainstreaming the former into the overall socio-economic decision-making process. As a matter of fact, China has been in the struggle against environmental pollution since the very beginning of its economic take-off and trying to explore a pathway that could help address China's environmental issues in the way most suitable to China's specific circumstances.

In recent years, especially since the 12th Five-Year Plan period, the enhanced measures including legislation, policy, regulatory and economic means have been taken by the Chinese government in dealing with environmental problems, of which environmental policies have played an important role in this regard. Corresponding to this situation and in meeting the demand of governments at different levels for environmental policy tools, the environmental policy research projects on topics of a wide range have been conducted by some Chinese environmental research institutions including the Chinese Academy for Environmental Planning (CAEP).

CAEP founded in 2001, is a research advisory body supporting governments in the development of key environmental planning, national environmental policies, and major environmental engineering projects. In the past more than 10 years, CAEP has accomplished the development of the overall planning of national environmental protection for the 10th, 11th and 12th Five-Year Plan periods; water pollution prevention and control planning for key river basins; air pollution prevention and control planning for key regions; soil pollution prevention and control planning; and some regional environmental protection plans. In the same period of time, CAEP also actively engaged in research on such topics as green GDP, environmental taxation, emission trading, ecological compensation, green financing, etc. By so doing, CAEP has become an indispensable advisory body in the environmental decision-making in mainland China. According to *2013 Global Go To Think Tanks Report and Policy Advice* published by University of Pennsylvania, CAEP was ranked 31 in the field of environment in the world. Many of CAEP's research results and project outcomes regarding environmental policies have drawn great attention of decision makers and international institutions, and have been utilized to contribute to the formulation of national environmental policies concerned.

The Chinese Environmental Policy Research Working Paper (CEPRWP) is a new internal publication produced by CAEP for the purpose of facilitating the academic exchange with foreign colleagues in this field, in which the selected research papers on environmental policies from CAEP are set out on the irregular basis. It is expected that this publication will not only make CAEP's research results on environmental policies be known by foreign colleagues but also serve as a catalyst for creating opportunity of international cooperation in the field of environmental policies, and environmental economics in particular, with a view of both the academic research and practical policy needs.

This report is product of cooperation project between Chemicals Branch, Division of Technology, Industry and Economics, United Nations Environment Programme (UNEP) and CAEP, Ministry of Environmental Protection (MEP), China under Small-Scale Funding Agreement (No.NF/4030-10-62-2201) signed in 27th Jan, 2011 with 30,000USD funds from UNEP to CAEP (Phase I) and a continuation SSFA was (No. NF/4030-10-85) signed in 26th, Nov, 2012 with 28,500 USD funds from UNEP to CAEP as supporting (Phase II).

In phase I, the project aims to adopt international best practice and policy evaluation tools to assess policy performance of China's Total Emission Reduction Policy in the period of 2006-2010 (11th FYP) at national level and pilots study in provincial level. While in the research, the project has adopted Driving forces-Pressures-State-Impacts-Responses (DPSIR) conceptual framework to form an indictaors-based evaluation system to assess the policy performance at implementation stage.

In phase II, the project has three research tasks: 1 Revise the indictaors-based evaluation system at national level according to the new requirements of the policy in 12th FYP (2011-2015) in which two complusory reduction pollutants became to four; 2 Establish indictaors-based evaluation system for provincial and municipal level based on statistical characteristics; 3 Develop indictaors-based evaluation system for sectoral level, the pilot study was carried out in textile sector.

Upon the project completion in 2013, it has quantified Total Emission Reduction Policy performance at national level between 2006 and 2010 and proposed a series of mature methods for assessing performance of emission reduction policy at provincial, municipal and sectoral level.

Contents

1. INTRODUCTION

The "Planning of the Eleventh Five Year Plan for National Economic and Social Development of the People's Republic of China" proposed the restrictive indicators of 10% total emission reduction of major pollutants in the 11th Five Year Plan period: in 2010, discharge of chemical oxygen demand (COD) and sulfur dioxide (SO_2) in the country will drop 10% respectively compared with 2005, i.e. discharge of chemical oxygen demand will be reduced from 14.142 million tons in 2005 to 12.728 million tons and emission of sulfur dioxide reduced from 25.494 million tons in 2005 to 22.944 million tons. To fully achieve the emission reduction goal set in the Eleventh Five Year Plan, the State Council formulated the "Comprehensive Work Plan of Saving Energy and Diminishing Pollution", in accordance with which the Ministry of Environmental Protection (MEP) gradually established and developed the emission reduction system including emission reduction evaluation, monitoring, statistics, examination, dispatching, direct reporting, filing, early warning and information disclosure and, jointly with the departments concerned, promulgated and implemented a series of policy documents including "Energy Saving Environmental Protection Power Generation Dispatching Method (Trial Implementation)", "Method for Managing the Operation of Desulphurization Facilities for Coal Fired Power Generating Units and Electricity Price" and "Interim Measures on State Revenue Special Fund Management for Emission Reduction of Major Pollutants". Governments at all levels further changed their concepts, improved emission reduction mechanism and system and developed a top down emission reduction implementation mechanism. With joint efforts made by all parties, pollution emission reduction made significant progress. In 2010, total discharge of chemical oxygen demand in China was 12.381 million tons and total emission of sulfur dioxide was 21.851 million tons, reduced 12.45% and 14.29% respectively compared with 2005, both over fulfilling the 10% emission reduction goal.

The "Planning of the Twelfth Five Years Plan for National Economic and Social Development" further proposed the total emission control target in the Twelfth Five Year Plan period: in 2015, energy consumption and carbon dioxide emission per unit GDP will drop 16% and 17% respectively, COD and SO_2 drop 8% respectively and ammonia nitrogen and nitric oxides drop 10% respectively. Minister ZHOU Shengxian pointed out, in the signed article "Deeply advance the reform and innovation of environmental protection system and actively explore China's new environmental protection road", that in meeting the requirements of the Outline, the overall consideration for China's environmental protection work in the Twelfth Five Years Plan period is: focus on the theme of scientific development, the main line of changing economic development pattern and the new requirements for improving ecological civilization level to actively explore a low cost, high benefit, low emission and sustainable new environmental protection road; lay stress on solving the prominent environmental problems that affect scientific development and impair the masses' health to plan as a whole the relations between total emission reduction and environmental quality improvement, environmental risk prevention and balanced urban and rural development, further optimize economic development and guarantee the improvement of people's livelihood.

Improving environmental quality has become the basic destination and important goal for the environmental protection work in the Twelfth Five Year Plan period.

Hence the Twelfth Five Years Plan has proposed new requirements for pollution emission reduction work: firstly, in emission reduction contents, ammonia nitrogen and nitric oxides are added to the pollutants for total emission reduction and the range of total emission reduction is enlarged. Secondly, in emission reduction goals, it is required that not only the total emission control goal should be accomplished but also the total emission reduction work should be linked with environmental quality improvement, environmental risk prevention and balanced urban and rural development. Thirdly, in emission reduction approaches, total emission reduction shall embody the requirements for building a low cost, high benefit, low emission and sustainable new environmental protection road. To further increase the pertinence of pollution emission reduction policies and enhance the performance of pollution emission reduction policies, it is urgently needed to analyze the emission reduction work effect in the Eleventh Five Year Plan period in a comprehensive and objective way, recognize and summarize the actual experience and weak link of total emission reduction work to set the stage for designing the emission reduction policies and schemes for the Twelfth Five Years Plan period and exploring the low cost, high benefit, low emission and sustainable new environmental protection road.

Based on the above goals, the Department of International Cooperation and the Department of Total Pollutants Control of the Ministry of Environmental Protection and the Chemicals Branch of United Nations Environment Programme have jointly initiated China Pollution Emission Reduction Performance Assessment Program.

This report is one of the main outputs of this program and it mainly introduces the learning results of international experience and the performance assessment methods of the Eleventh Five Year Plan emission reduction policy established in accordance with China's actual conditions. Finally, it provides a comprehensive analysis of pollution emission reduction conditions and effects in the Eleventh Five Year Plan period based on the available data and puts forward suggestions on the formulation and implementation of the total emission reduction policies in the Twelfth Five Year Plan.

1.1 Main contents of the Eleventh FYP emission reduction policies

1.1.1 Emission reduction goal

In order to improve China's environmental quality, reduce environmental pollution emission, adjust industrial structure, change development pattern, solve regional environmental problems and mitigate the contradictions between environmental pollution and economic development, the Party Central Committee and the State Council promptly proposed the restrictive indicators of 10% total emission reduction of major pollutants in the 11th Five Year Plan period: in 2010, emission of chemical oxygen demand and sulfur dioxide in the country will drop 10% respectively compared with 2005, i.e. discharge of chemical oxygen demand will be reduced from 14.14 million tons in 2005 to 12.7 million tons and emission of sulfur dioxide reduced from 25.49 million tons in 2005 to 22.95 million tons (Table 2), to set the stage for implementing the scientific concept of development and promote a harmonious society.

Table 2: Major Pollution Emission Reduction Indicators in 11th FYP Period

Indicators	2005	2010	Reduction goal
COD discharge (10,000t)	1414	1270	-10%
SO2 emission (10,000t)	2549	2295	-10%
Proportion of water quality worse than Grade V in surface water monitored sections (%)	26.1	<22	-4.1 percentage points
Proportion of water quality better than Grade Ⅲ in main water system monitored sections (%)	41	>43	2 percentage points
Proportion of air quality equal to or above Grade II over 292 days in major cities (%)	69.4	75	5.6 percentage points

1.1.2 Emission reduction measures

1) Established clearly work-divided target-related responsibility system and supervision and evaluation system

In order to achieve the 11th FYP pollution reduction goal, all provinces (regions and municipalities) established a leading group for energy conservation and pollutant discharge reduction led by the main leaders of provincial governments to exercise strict evaluation and accountability and form a vertically interlocked and departmentally coordinated pollution emission reduction work mode. Strengthened government responsibilities and decomposed reduction task level by level to decompose rigid and quantified reduction indicators to governments and enterprises at all level. Adopted the three major systems including “scientific pollution emission reduction statistical system”, “accurate emission reduction monitoring system” and “strict emission reduction evaluation system” to scientifically, promptly, accurately and comprehensively reflect the emission condition and change trend of major pollutants and promptly tracked the emission change of major pollutants in all regions and from major enterprises to develop an energy conservation and emission reduction target-related responsibility system with definite goals and clear responsibilities where one level monitors and evaluates the other.

2) Comprehensively used multiple means to implement emission reduction responsibilities

In the Eleventh Five Year Plan period, China took several pollution emission reduction measures such as facility reduction, structural reduction and management reduction and effectively guaranteed the accomplishment of the 11th FYP pollution emission reduction goal. For facility reduction, in 2010, 107 million kW installed capacity of coal fired desulphurization units was added and installed capacity of thermal power desulphurization units reached 578 million kW and its proportion in the total number of thermal power units increased from 12% in 2005 to 82.6%; 19 million m^3 daily municipal wastewater treatment capacity was added and daily municipal wastewater treatment capacity reached 125 million m^3 and municipal wastewater treatment rate increased from 52% in 2005 to over 75%; 170 FGD units for steel and iron sintering machines were built and operated and its proportion in the total of sintering machines increased from 0% in 2005 to 15.6% in 2010.

For structural reduction, totally 72.1 million kW small thermal power units were decommissioned and the task of decommissioning 50 million kW was accomplished 1.5 years ahead of schedule. Elimination of backward production capacity was carried out for high energy consuming and high emission industries such as iron & steel, cement, coking and paper making, alcohol and monosodium glutamate, including 110 million tons of iron making capacity, 68.6 million tons of steelmaking, 330 million tons of cement, 93 million tons of coke, 7.2 million tons of paper making, 1.8 million tons of alcohol, 0.3 million tons of monosodium glutamate and 38 million weight cases. In 2010, the proportion of installed capacity of >300MW thermal power units in the national electrical power industry increased from 47% in 2005 to over 70% and coal consumption for thermal power supply dropped 9.5% and COD pollution discharge load per unit product in the paper making industry dropped 45%.

For management reduction, the state revenue provided more than 10 billion Yuan in the Eleventh Five Year Plan period to support the construction of the “Three Major Systems” for pollution emission reduction and the environmental protection supervision and management capacity in the country. 343 pollution source monitoring and control centers were built to automatically monitor and control 15,000 enterprises and more than 100,000 sets of monitoring and law enforcement equipment were arranged; thus environmental supervision and management ability was markedly enhanced. China Southern Power Grid Co. Ltd and many provinces carried out energy conservation, emission reduction, power generation and dispatching to evaluate the operation rate of coal fired desulphurization units and deduct desulphurization electricity price and operation rate increased from less than 60% in 2005 to more than 95% in 2010. Compliance rate of SO_2 and COD from key pollution sources under national monitoring program was 92% and 94% respectively, up 22% and 34% compared with 2005.

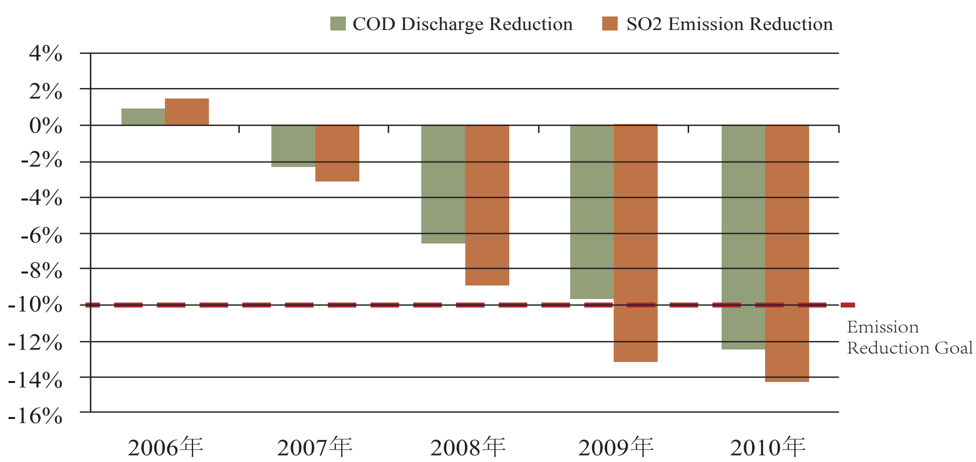
3) Strengthened the systems and capacity guarantee for determining and implementing the goal set in the plan

In order to accomplish the pollution emission reduction goal set in the Eleventh Five Year Plan, the “Guidelines for Preparing the Total Emission Reduction Plan for Major Pollutants (Trial Implementation)” and the “Detailed Rules for Calculating Total Emission Reduction of Major Pollutants (Trial Implementation)” were printed and issued and the environmental management systems such as emission reduction evaluation, statistics, monitoring, examination, dispatching, direct reporting, filing, information disclosure and early warning were adopted to ensure continuous advance of emission reduction. To ensure that emission reduction data was true and creditable, the Ministry of Environmental Protection organized forces biannually to examine emission reduction on the spot in all regions and it stipulated that local emission reduction results could not be openly released until approved by the Ministry of Environmental Protection. “Regional Restricted Approval” by enhancing project admittance conditions has controlled new pollution from the development source. Carried out special environmental protection activities and severely investigated and prosecuted environmentally unlawful act. Organized several national training sessions for pollution emission reduction work and technical training sessions for examination methods and detailed accounting rules and trained more than 2,000 persons (times) of leaders and administrative and technical personnel at all levels responsible for emission reduction in the national environmental protection system. Governments at all levels strengthened pollution emission reduction management and law enforcement capacity building and focused on the need of pollution emission reduction work to enhance pollution emission reduction management and law enforcement force.

4) Completion condition of emission reduction

Guaranteed by a series of emission reduction policy measures, China over-fulfilled the pollution emission reduction goal set in the Eleventh Five Year Plan. In 2010, China's COD discharge was 12.381 million tons, down 12.5% compared with 2005. SO_2 emission was 21.851 million tons, down 14.3% compared with 2005 (Figure 4). Installed capacity of desulphurization units in the country reached 461 million kW and annual desulphurization capacity was 12 million tons. The proportion of installed capacity of desulphurization units in total installed capacity of thermal power rose from 12% to 71% and municipal wastewater treatment rate rose to 75%. The proportion of water quality better than Grade III in main water system monitored sections increased from 41% in 2005 to 59.9% in 2010, proportion of water quality worse than Grade V in surface water monitored section dropped to 16.4% and proportion of air quality equal to or above Grade II over 292 days in major cities exceeded 95%, all achieving the goal set in the Eleventh Five Year Plan. Average concentration of permanganate indicators in surface water monitored sections dropped 24% compared with 2005 and the proportion of main environmental protection cities with air quality equal to Grade II increased from 40.7% to 67.3%.

■ **Figure 4: Pollution Emission Reduction in Eleventh Five Year Plan Period**



1.2 Significance for performance assessment

Performance assessment is an open and effective environmental management tool and an important link in environmental policy execution process. Appropriate indicators are used to measure and assess the environmental effects gained after environmental policies are implemented so as to measure the advantages and disadvantages of regional environmental policies, reveal the change situation of environmental policies, enhance public environmental consciousness and guide environmental policies to sound development. Environmental performance not only refers to the environmental effect generated from environmental management activities but also contains cost factor input to improve environmental conditions, thus being a concept that embodies environmental protection efficiency.

Under the economic development circumstance that China's average GDP growth rate exceeds 10%, Chinese Government has implemented the 11th FYP pollution emission reduction policies and over fulfilled the pollution emission reduction tasks for COD and SO_2 pollutants etc. However, except the emission reduction indicators of pollutants like COD and SO_2 have made this achievement, what improvements have been made by the implementation of emission reduction policies in pollution control ability, environmental quality, enterprise production and pollution control technological advance and industrial and national economic structural optimization? Scientific and rational indicators need to be chosen to measure the effects gained from the implementation of pollution emission reduction performance.

At the same time, implementation and completion of any polices need costs. In order to achieve the 11th FYP pollution emission reduction task, Chinese Government took measures like facility reduction, structural reduction and management reduction to increase investments in treatment of pollution industries, eliminate backward production capacities of a series of industries including thermal power, coking, cement, paper making, alcohol, monosodium glutamate and citric acid and set up special funds for pollutants emission reduction to support the "Three Major Systems" for countrywide pollution emission reduction and environmental protection supervision and management capacity building. In order to scientifically reflect the efficiency of pollution emission reduction policies, it is necessary to calculate various costs and fees for pollution emission reduction so as to compare the effects and costs of pollution emission reduction, analyze the "efficiency" of pollution emission reduction in depth and systematically and provide a better scientific basis for China to choose various policies to carry out pollution emission reduction in the Twelfth Five Year Plan period.

Thirdly, as resource environment and global climate change crisis is increasing gradually, international communities and domestic public pay higher and higher attention to environmental problems and environmental protection departments and especially informatization and networkization development gradually reduces information transmission. Sudden and regional pollution problems can very easily trigger the extensive attention of social public to pose huge pressure to government sectors. Although China has accomplished the 11th FYP pollution emission reduction task, the people hold different views on the improvement of environmental quality brought about by pollution emission reduction. For this reason, public satisfaction with environmental quality needs to be surveyed to truly reflect the efforts made by environmental protection departments to improve environmental quality on the one hand, and assess the real effects of environmental quality improvement by a series of environmental policies including total pollutants control on the other hand. By disclosing the assessment results to the public to increase public right to learn the truth, it is possible to effectively release the pressure from the international community and domestic public and eventually promote the smooth progress of environmental protection work.

2. METHODOLOGY FOR ASSESSING THE PERFORMANCE OF EMISSION REDUCTION POLICIES

2.1 Driving Forces-Pressures-State-Impacts-Responses (DPSIR) framework

DPSIR indicator framework originally known as the Stress-Response framework developed by two scientists working at Statistics Canada, Anthony Friend and David Rapport (Rapport and Friend, 1979). In 1991 in OECD this model has evolutes to PSR (Pressure-Stress-Response) framework within added new features of Pressure indicators. With the development of the large environmental models such as RAINS (Regional Air Pollution Information and Simulation) and IMAGE (Integrated Model to Assess the Global Environment) by IIASA (International Institute for Applied Systems Analysis) and RIVM (Dutch National Institute for Public Health and the Environment) respectively, the DPSIR model became further formalized. The new features including a more precise differentiation between driving forces, pressures, the resulting state of systems, the impacts (among others on the economy) and policy responses. Later the EEA helped to make this final DPSIR framework more widely known in Europe since 1995. From 2001 EEA started published its indicators on web.

In a systematic and analytic view, DPSIR framework helps understanding environmental changes caused by societal activities. First social and economic developments as Driving-forces exert Pressures on the environment and, therefore, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Consequently, the changes leads to Impacts on human health, ecosystems and natural system that may trigger societal Responses that affect back on the Driving forces or on the state or impacts directly. DPSIR is not only a more complicated framework but also a more comprehensive and sophisticate framework

Driving forces describe the social, demographic and economic developments in societies and the corresponding changes in lifestyles, overall levels of consumption and production patterns. Primary driving forces are population growth and developments in the needs and activities of individuals. These primary driving forces provoke changes in the overall levels of production and consumption. Through these changes in production and consumption, the driving forces exert pressure on the environment.

Pressure indicators describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities. The pressures exerted by society are transported and transformed through variety of natural processes to manifest themselves in changes of environmental conditions.

State indicators give a description of the quantity and quality of physical phenomena (such as temperature), biological phenomena (such as fish stocks) and chemical phenomena (such as atmospheric CO_2 concentrations) in a certain area. State indicators, for instance, may describe the forest and wildlife resources present, the concentration of phosphorus and sulfur intakes, or the level of noise in the neighborhood of airports.

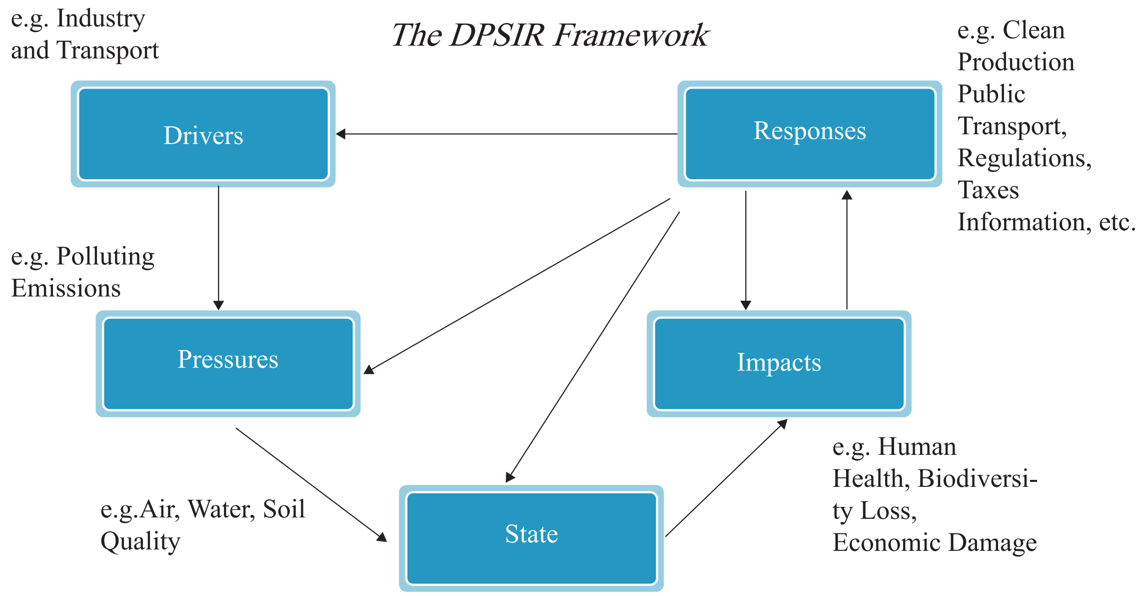
Pressures on the environment cause the state of the environment changes. These changes then have impacts on the functions of the environment, such as human and ecosystem health, resources availability, losses of manufactured capital, and biodiversity. Impact indicators are used to describe changes in these conditions.

Response indicators refer to responses by groups (and individuals) in society, as well as government attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment.

DPSIR system can macroscopically help the mankind understand the relation between social activities and environmental change. Firstly, social and economic development is defined as driving force, the source of environmental pressure, and it forces environmental condition to change. For example, the appropriate conditions provided for health, resource availability and biodiversity all cause changes. These changes bring impact to human health, ecosystem and natural system that may trigger social response which in turn directly affects driving force or state or impact. DPSIR is not only a complicated cycle framework but also a comprehensive and complete logic framework.

As the most direct response of the government to environmental problems, it is seen from Figure 5 that the change of environmental policies can change environmental pressure, state and impact and further cause the driving force to change, which eventually leads to the adjustment of human production and consumption behaviors. To measure the effect of energy conservation and emission reduction policies, in addition to analyzing whether the energy conservation and emission reduction goal set by our country is achieved, it is necessary to judge whether environmental supervision ability is strengthened, environmental quality is improved, economic development mode is changed and mechanism including environmental protection in comprehensive decision making is established. Emission reduction goal and pollutants emission reduction amount reflect environmental pressure change, environmental quality reflects state change, environmental supervision ability reflects direct effect of response, economic development mode change reflects the impact of emission reduction policies on the driving force that causes environmental change, and including environmental protection in comprehensive decision making reflects the comprehensive effect of various policies. Therefore, performance analysis of emission reduction policies can be interpreted by a complete DPSIR framework.

■ **Figure 5: DPSIR Framework**



The Driver-Pressure-State-Impact-Response（DPSIR) framework(EEA,1995; Turner et al, 1998)

2.2 DPSIR-based performance descriptive indicators

2.2.1 EEA and DPSIR formation

The European Environment Agency (EEA) is an agency of the European Union. The European Union adopted the regulation establishing the EEA in 1990. It came into force in late 1993 immediately after the decision taken to locate the EEA in Copenhagen. Work started in earnest in 1994.

In EEA's classification system, all DPSIR indicators belong to Descriptive Indicators category which named Type A by EEA. Other categories are including Type B: Performance Indicators, Type C: Efficiency Indicators, Type D: Policy-effectiveness Indicators and Type E: Welfare Indicators. Therefore, DPSIR framework should not cross confusing with ABCDE classification system.

However, in some case, DPSIR indicators not represent the characteristics of descriptive indicators only, but also contain some features of other type of indicators. For instance, an Impact indicator could be on behalf of either descriptive indicators (A) or policy-effectiveness indicators (B) at the same time (more details will discuss later).

Table 3: Terminology and typology of EEA

Name	Type in EEA system	Contents	Feasible in Environmental Performance Assessment?	Implication
Descriptive Indicators	A	Driving-force Indicators Pressure Indicators Stress Indicators Impact Indicators Response Indicators	Yes	Describe environmental status and logical chain behind it
Performance Indicators	B	They measure the distance between current environmental situation and the desired situation (target)	No	Make prediction on environmental progress
Efficiency Indicators	C	They provide insight in the efficiency of products and processes. Efficiency in terms of the resources used the emissions and waste generated per unit of desired output.	No	Identify the efficiency of environmental services
Policy-Effectiveness Indicator	D	Policy effectiveness indicators relate the actual change of environmental variables to policy efforts. As such, they are a link between response indicators on one hand and state, driving force, pressure or impact indicators on the other.	Yes	Check the effectiveness of environmental improvements
Total Welfare Indicators	E	N/A	No	Evaluate economic contribution environment

2.2.2 Global well-recognized environmental indicators

Many international organizations e.g. OECD (Organization for Economic Cooperation and Development), UNEP (United Nations Environment Programme) and EEA (European Environment Agency) publish their own environmental indicators respect for various environmental issues annually or biannually. Sometimes the expression and/or unit of the indicators may slightly change in order to adapt the new situations and trends.

EEA and OECD have selected for taking a closer look of their environmental indicators. The table below is showing statistics of indicators development from both organizations. Beware that OECD is not an environment-oriented organization so the number of OECD's indicators in the table only represent environmental indicators in OECD indicator stock.

Table 4: Summary of indicators from OECD and EEA

Organization	Number of core set of Indicators	Number of Specific Indicators	First year publish	Scale
OECD	10	Around 30	2001	30 countries globally
EEA	10	37	2004	27 EU countries

Indicators development of OECD and EEA Source from: OECD 2008 and EEA 2005

The table below details the core environmental indicators extracted from both EEA (2004) and OECD (2008) publications. Many overlapped issues can observed from the table.

Table 5: Core environmental indicators in EEA and OECD

Core Environmental Indicator	EEA	OECD
1	Air pollution and ozone depletion	Air Quality
2	Biodiversity	Biodiversity
3	Climate Change	Climate Change
4	Terrestrial	Ozone layer
5	Waste	Waste Generation
6	Water	Freshwater Resources
7	Agriculture	Forest Resources
8	Energy	Energy Resources
9	Fisheries	Fish Resources
10	Transport	Freshwater Quality

Indicators development of OECD and EEA Source from: OECD 2008 and EEA 2005

The table below details the core environmental indicators extracted from both EEA (2004) and OECD (2008) publications. Many overlapped issues can observed from the table.

Based on DPSIR framework, UNEP has designed a set of relatively complete assessment indicator system for pollution emission reduction performance assessment (Refer to Table 3), pointed out the application method of the indicator system (Table 4) and emphasized that performance assessment of pollution emission reduction policies can be accomplished by description of a single indicators and additionally the impact of emission reduction policies can be quantitatively assessed by combinatory analysis among different indicators.

Table 6: DPSIR-Based Performance Analysis Indicators System

<table>
<tr><th colspan="3">Indicators classification</th><th>Characteristic indicators</th><th>Specific indicators</th></tr>
<tr><td rowspan="8">Driving force</td><td rowspan="6">Social and economic activities</td><td rowspan="2">Industrial</td><td rowspan="2">Industrial development</td><td>Added value of heavy pollution industries</td></tr>
<tr><td>Proportion of coal consumption</td></tr>
<tr><td rowspan="3">Domestic</td><td rowspan="3">Urbanization, e.g. car consumption and urban runoff increase</td><td>Motor vehicle quantity</td></tr>
<tr><td>Per capita energy consumption</td></tr>
<tr><td>Urbanization rate</td></tr>
<tr><td>Agricultural</td><td>Use of fertilizer and pesticide and their discharge to rivers</td><td>Consumption of chemical fertilizer and pesticide</td></tr>
<tr><td rowspan="2">Natural interference</td><td>Volcanic eruption</td><td>Volcanic eruption</td><td>Volcanic eruption frequency and intensity</td></tr>
<tr><td>Eutrophication</td><td>Natural eutrophication</td><td>Water body eutrophication frequency and extent</td></tr>
</table>

Indicators classification			Characteristic indicators	Specific indicators
Pressure	Emissions inventory		Effluent release and/or total emission total	Emission of SO_2, NO_x, COD and ammonia nitrogen
			Effluent release/emission from departments and/or cities	SO_2 emission from industrial sector
				NO_x emission from industrial sector
	Effluent reaction and deposition		Effluent concentration in air (average, short term, long term)	Proportion of SO_2 that forms sulfuric acid in air in total SO_2
			Effluent concentration in water body (average, short term, long term)	Proportion of compounds that incur chemical reaction in wastewater in total compounds
	Effluent destination	Air	Effluent concentration and emission amount in air compared with other types of effluents	Annual average precipitation of acid rain containing sulfate radical
		Water	Effluent concentration and discharge amount in water compared with other types of effluents	Proportion of water with COD beyond standard that flows to underground drinking water source, in total wastewater discharge
		Soil	Effluent concentration and discharge amount in soil compared with other types of effluents	Increased proportion of various pollutants in soil due to discharge of pollutants
State	Basic account		Emission concentration (annual base, air quality)	Annual average concentration of SO_2, PM_{10} and NO_x
			Chemical composition of air	Proportion of SO_2 and NO_2 in air
			Meteorological conditions	Annual average monsoon intensity (atmospheric pollutant transfer speed)
			Hydrologic regime	COD-contaminated water body transfer speed
	Ecosystem potential		Water area biodiversity indicators	Number of biologic species per unit water area
			Toxic substance accumulation	Concentration of toxic substance
			Habitat conditions	Urban air quality grade
				Number of acid rain affected cities
			Vulnerability stress and natural interference	Energy consumption per unit GDP

Indicators classification			Characteristic indicators	Specific indicators
Impact	Direct loss	Human health	Contaminated water and polluted air are related to diseases for treatment in hospital	Number of related disease outpatients
			Treatment in emergency department	Number of outpatients in emergency department
		Ecosystem	Pollutant concentration in soil and aquatic system	pH change rate
			Quantity of affected aquatic animals, plants, phytoplankton and zooplankton	Quantity of affected aquatic animals, plants, phytoplankton and zooplankton
		Resource	Reduce water availability	Number of water deficient cities or wastewater irrigation area
	Indirect loss	Human health	Diseases and bad health cause loss of working time	Economic loss from loss of working time due to health reason
		Ecosystem	Acid rain changes soil pH and leads to death of soil-dependent microorganisms and other organisms	Economic loss from land deterioration
			endangered species are extinct or lost	Economic loss due to biodiversity reduction
		Resource	Reduce air visibility (smog)	Losses from traffic accidents
			Acid rain causes damage to building materials, sculptures and monuments	Economic loss due to damage of building materials, sculptures and monuments
			Acid rain causes damage to metal (copper, bronze) statues and other irreplaceable materials	Economic loss due to material damage
			Impact on tourism	Economic loss due to attraction reduction of tourism
			Real estate	Economic loss due to reduction of investment in real estate
			Fishing capacity decrease	Economic loss due to reduction of fishery production
			Contaminated water and polluted air are related to diseases for treatment in hospital	Economic loss from loss of working time due to health reason
Response	Economic response		Increase pollution control infrastructure construction	Number of desulphurization facilities and wastewater treatment plants
			Facility investment	Total investment in pollution treatment facilities
			Government subsidy for industry	Subsidy amount related to emission reduction
			Increase pollution treatment capacity	New wastewater treatment capacity and new desulphurization facility desulphurizing capacity
	Management response		Ecological efficiency substitute conventional product	Proportion of energy saving and environmental protection products
			Industrial technological improvement	Proportion of enterprises that carry out cleaner production
			Emission standard and limit	Newly issued pollutants emission standard/limit

Table 7: Policy Performance Assessment Method

Class	Policy effect indicators	Function
Independent descriptive indicators	Response	Measure government work effort
	State	Check environmental quality improvement
	Pressure	Measure environmental pressure change
Combined descriptive indicators	Response-pressure	Measure emission reduction goal accomplishment
	Response-state	Measure whether environmental quality is improved
	Pressure-driving force	Measure whether economic structure is optimized

2.3 Establish emission reduction performance indicators system

2.3.1 Build the indicators system

The DPSIR indicators system provided by UNEP is relatively comprehensive but in terms of China's actual conditions, the data need for building this framework can not be fully met. Firstly, some indicators have not started statistics in the present statistical system in China and the data needed can not be obtained. Secondly, some indicators with data available are not closely related to the 11th FYP emission reduction performance and not suitable for being included as performance assessment indicators. See Table 5.

Table 8: DPSIR Indicators Framework Provided by UNEP

Indicators classification			Characteristic indicators	Specific indicators	suggestions
Driving force	Social and economic activities	Industrial	Industrial development	Added value of heavy pollution industries	Included; COD and SO_2 emission intensity of industrial added value of first 5 heavy pollution industries are adopted
				Proportion of coal consumption	Not included; recommended as analysis indicators
		Domestic	Urbanization, e.g. car consumption and urban runoff increase	Motor vehicle quantity	Not included; key point of emission reduction in 12th FYP period, can be used as analysis indicators
				Per capita energy consumption	Not included; recommended as analysis indicators
				Urbanization rate	Not included; recommended as analysis indicators
		Agricultural	Use of fertilizer and pesticide and their discharge to rivers	Consumption of chemical fertilizer and pesticide	Not included; key point of emission reduction in 12th FYP period, can be used as analysis indicators
	Natural interference	Volcanic eruption	Volcanic eruption	Volcanic eruption frequency and intensity	Not included
		Eutrophication	Natural eutrophication	Water body eutrophication frequency and extent	Not included; difficult to distinguish from natural and artificial eutrophication

Indicators classification			Characteristic indicators	Specific indicators	suggestions
Pressures	Emissions inventory		Emissions inventory Effluent release and/or total emission total	Emission of , NO_x, COD and ammonia nitrogen	SO_2 and COD included
			Effluent release/emission from departments and/ or cities	SO_2 emission from industrial sector	Included as analysis indicators
				NO_x emission from industrial sector	Included as analysis indicators
	Effluent reaction and deposition		Effluent concentration in air (average, short term, long term)	Proportion of SO_2 that forms sulfuric acid in air in total SO_2	Not included; lack of data support
			Effluent concentration in water body (average, short term, long term)	Proportion of compounds that incur chemical reaction in wastewater in total compounds	Not included; lack of data support
	Effluent destination	Air	Effluent concentration and emission amount in air compared with other types of effluents	Annual average precipitation of acid rain containing sulfate radical	Not included; lack of data support
		Water	Effluent concentration and discharge amount in water compared with other types of effluents	Proportion of water with COD beyond standard that flows to underground drinking water source in total wastewater discharge	Not included; lack of data support
		Soil	Effluent concentration and discharge amount in soil compared with other types of effluents	Increased proportion of various pollutants in soil due to discharge of pollutants	Not included; lack of data support
State	Basic account		Emission concentration (annual base, air quality)	Annual average concentration of SO_2, PM_{10} and NO_x	Not included as urban air quality grade includes the above factors
			Chemical composition of air	Proportion of SO_2 and NO_2 in air	Not included; lack of data support
			Meteorological conditions	Annual average monsoon intensity (atmospheric pollutant transfer speed)	Not included; lack of data support
			Hydrologic regime	COD-contaminated water body transfer speed	Not included; lack of data support
	Ecosystem potential		Water area biodiversity indicators	Number of biologic species per unit water area	Not included; lack of data support
			Toxic substance accumulation	Concentration of toxic substance	Not included; lack of data support
			Habitat conditions	Urban air quality grade	Included; the proportion of air quality equal to or above Grade II over 292 days in major cities is used for comprehensive reflection
				Number of acid rain affected cities	Included; the number of cities with acid rain occurrence among the monitored cities is adopted
			Vulnerability stress and natural interference	Desertification area	Not included; not closely related to this assessment

Indicators classification			Characteristic indicators	Specific indicators	suggestions
Impact	Direct loss	Human health	Contaminated water and polluted air are related to diseases for treatment in hospital	Number of related disease outpatients	Included; economic loss due to air pollution is adopted for comprehensive reflection
			Treatment in emergency department	Number of outpatients in emergency department	Included; economic loss due to air pollution is adopted for comprehensive reflection
		Ecosystem	Pollutant concentration in soil and aquatic system	pH change rate	Not included; lack of data support
			Quantity of affected aquatic animals, plants, phytoplankton and zooplankton	Quantity of affected aquatic animals, plants, phytoplankton and zooplankton	Not included; lack of data support
		Resource	Reduce water availability	Number of water deficient cities or wastewater irrigation area	Not included
	Indirect loss	Human health	Diseases and bad health cause loss of working time	Economic loss from loss of working time due to health reason	Included; economic loss due to air pollution is adopted for comprehensive reflection
		Ecosystem	Acid rain changes soil pH and leads to death of soil-dependent microorganisms and other organisms	Economic loss from land deterioration	Not included; lack of data support
			endangered species are extinct or lost	Economic loss due to biodiversity reduction	Not included; lack of data support
		Resource	Reduce air visibility (smog)	Losses from traffic accidents	Not included; lack of data support
			Acid rain causes damage to building materials, sculptures and monuments	Economic loss due to damage of building materials, sculptures and monuments	Included; economic loss due to air pollution is adopted for comprehensive reflection
			Acid rain causes damage to metal (copper, bronze) statues and other irreplaceable materials	Economic loss due to material damage	Not included; lack of data support
			Impact on tourism	Economic loss due to attraction reduction of tourism	Not included; lack of data support
			Real estate	Economic loss due to reduction of investment in real estate	Not included; lack of data support
			Fishing capacity decrease	Economic loss due to reduction of fishery production	Not included; lack of data support
			Contaminated water and polluted air are related to diseases for treatment in hospital	Economic loss from loss of working time due to health reason	Included; economic loss due to air pollution is adopted for comprehensive reflection

Indicators classification		Characteristic indicators	Specific indicators	suggestions
Response	Economic response	Increase pollution control infrastructure construction	Number of desulphurization facilities and wastewater treatment plants	Reflected by desulphurizing capacity and wastewater treatment capacity
		Facility investment	Total investment in pollution treatment facilities	Included
		Government subsidy for industry	Subsidy amount related to emission reduction	Not included; lack of data support
		Increase pollution treatment capacity	New wastewater treatment capacity and new desulphurization facility desulphurizing capacity	Included
	Management response	Ecological efficiency substitute conventional product	Proportion of energy saving and environmental protection products	Not included; lack of data support
		Industrial technological improvement	Proportion of enterprises that carry out cleaner production	Not included; lack of data support
			Newly issued pollutants emission standard/limit	No new standards or limitations are issued

After the indicators that are unrelated and lack data support are removed, the obtained indicators system is regarded as the DPSIR indicators system that tallies with China's national conditions. In addition, considering that China's pollution response measures not only include environmental protection treatment investment but also include increase of pollution treatment facility operation efficiency brought about by personnel training and supervision strengthening, , the indicators of annual average load rate of treatment facilities in wastewater treatment plants and the comprehensive desulphurization efficiency of desulphurization facilities in the electric power industry are added to the indicators of the response part. For the adjusted indicators, refer to Table 6.

Table 9: Emission Reduction Performance Assessment Indicators System Tallying with China's National Conditions

Comprehensive indicators	Specific indicators	Indicators No.
Policy response	Proportion of total investment in pollution treatment in GDP (100,000,000 Yuan)	(1)
	Removal rate of industrial sulfur dioxide (%)	(2)
	Municipal domestic wastewater treatment rate (%)	(3)
	Annual average operation rate of industrial wastewater treatment facilities (%)	(4)
	Annual average operation rate of treatment facilities in wastewater treatment plants (%)	(5)
	Comprehensive desulphurization efficiency of electric power industry (%)	(6)
	Eliminated quantity of backward production capacities (100,000,000 Yuan)	(7)
	Stable network connection proportion of on-line monitoring facilities in key national monitored enterprises (%)	(8)

Comprehensive indicators	Specific indicators	Indicators No.
Environmental pressure	COD discharge (10,000 t)	(9)
	SO_2 emission (10,000 t)	(10)
Environmental state	Proportion of air quality equal to or above Grade II over 292 days in major cities (%)	(11)
	Proportion of cities with acid rain occurrence among monitored cities (%)	(12)
	Proportion of water quality worse than Grade V in surface water monitored section (%)	(13)
	Proportion of water quality better than Grade III in main water system monitored sections (%)	(14)
Comprehensive impact	Public satisfaction with urban environmental protection (%)	(15)
	Economic loss due to atmospheric pollution (100,000,000 Yuan)	(16)
	SO_2 emission intensity per 10,000 Yuan industrial added value in heavy pollution industries (kg/10,000 Yuan)	(17)
	COD discharge intensity per 10,000Yuan industrial added value in heavy pollution industries (kg/10,000 Yuan)	(18)
Global environment	CO_2 emission reduction due to close-down of backward production capacities (100,000,000 t)	(19)

2.3.2 Indicators definition and calculation method

(1) Proportion of total investment in pollution treatment in GDP: refers to the proportion of investment in environmental pollution treatment in the current year gross domestic product.

(2) Removal rate of industrial sulfur dioxide: refers to the proportion of removal amount of industrial sulfur dioxide in production amount of industrial sulfur dioxide. Production amount of industrial sulfur dioxide =emission amount of industrial sulfur dioxide + removal amount of industrial sulfur dioxide.

(3) Annual average operation rate of industrial wastewater treatment facilities: refers to the proportion of wastewater amount actually treated by industrial wastewater treatment facilities in designed treatment capacity. Calculation equation:

Industrial wastewater treatment amount÷365÷treatment capacity of industrial wastewater treatment facilities×100%

(4) Annual average operation rate of municipal wastewater treatment plants: refers to the proportion of wastewater amount actually treated by municipal wastewater treatment plants and centralized wastewater treatment equipment in industrial zone in the current year in the design treatment capacity. Calculation equation:

Annual average operation rate of municipal wastewater treatment plants

= (wastewater treatment amount÷365)

÷ [(design treatment capacity of wastewater treatment plants + treatment capacity of centralized treatment equipment

÷10000)] ×100%

(5) Comprehensive desulphurization

efficiency of electric power industry: refers to the ratio of removal amount of sulfur dioxide from production and supply of electric power and thermal power to production amount of sulfur dioxide in the current year in Annual Report of Environmental Statistics.

Comprehensive desulphurization efficiency =removal rate of sulfur dioxide÷(removal amount of sulfur dioxide +emission amount of sulfur dioxide)×100%

(6) Eliminated quantity of backward production capacities: calculated on the basis of product value produced by eliminated production capacity. The target value of eliminated backward production capacity is calculated in accordance with the directory of eliminations listed in the Comprehensive Work Plan on Energy Conservation and Emission Reduction during 11th Five-Year Plan Period issued by the State Council.

(7) Stable network connection proportion of on-line monitoring facilities in key national monitored enterprises: refers to proportion of COD monitoring equipment and SO_2 monitoring equipment (sets) quantity in the key national monitored enterprises that already carry out automatic monitoring, in stable network connection with environmental protection departments. Calculation equation:

Stable network connection proportion of on-line monitoring facilities in key national monitored enterprises

= (COD monitoring equipment (sets) quantity in stable network connection with environmental protection departments)

+ SO_2 monitoring equipment (sets) quantity in stable network connection with environmental protection departments number of key national monitored enterprises that already carry out automatic monitoring×100%

*Since Annual Report of Environmental Statistics 2010 no longer involves the related indicators of SO_2/COD monitoring equipment (sets) quantity in stable network connection with environmental protection departments, the calculation equation of this indicators for 2010 data is: the number of key national monitored enterprises that already carry out automatic monitoring ÷ number of key national monitored enterprises that already have network connection for automatic monitoring

(8) COD discharge: refers to the actual COD discharge amount at the end of the current year

(9) SO_2 emission: refers to the actual SO_2 emission amount at the end of the current year

(10) Proportion of air quality equal to or above Grade II over 292 days in major cities: refers to the proportion of major cities with annual air quality equal to or above Grade II over 292 days in the total number of major cities.

(11) Proportion of cities with acid rain occurrence among monitored cities: refers to the proportion of monitored cities with acid rain occurrence in the total number of monitored cities in the current year.

(12) Proportion of water quality worse than Grade V in surface water monitored section: refers to the proportion of surface water monitored sections with water quality worse than Grade V in the total number of surface water monitored sections

(13) Proportion of water quality better than Grade III in main water system monitored

sections: refers to the proportion of monitored sections of the seven major water systems with water quality better than Grade III in the total monitored sections of the seven major water systems.

(14) Public satisfaction with urban environmental protection: refers to the overall evaluation of the public for urban environmental protection conditions. It is calculated from the satisfaction average of all evaluated cities on the basis of results of the annual "Urban Investigation" public satisfaction survey conducted by the Department of Pollution Prevention and Control of the Ministry of Environmental Protection. As this indicators was included in Urban Investigation for the first time in 2007, there are no 2005 and 2006 data.

(15) Economic loss due to atmospheric pollution: the loss due to atmospheric pollution is calculated for value mainly by the losses to human health, agriculture, buildings and cleaning caused by atmospheric pollution. Loss of human health due to atmospheric pollution mainly includes three aspects: loss of early death due to pollutant PM_{10}, loss of excessive inpatients related to respiratory system and circulatory system, and disability loss; agricultural loss mainly includes loss of agricultural production reduction and quality reduction due to SO_2 and acid rain; loss of building corrosion mainly includes loss of service life reduction of various building materials due to acid rain. Cleaning cost mainly includes outdoor cleaning cost and indoor cleaning cost due to pollutants like dust. As SO_2 is the emission reduction indicators in the Eleventh Five Year Plan period, this report only calculates the loss of agricultural pollution and loss of building corrosion related to SO_2. Atmospheric pollution loss indicators data is from the environmental and economic accounting program organized by Chinese Academy for Environmental Planning.

(16) SO_2 emission intensity per 10,000 Yuan industrial added value in heavy pollution industries: refers to the SO_2 emission intensity of 10,000Yuan industrial added value of the first 5 heavy pollution industries in SO_2 emission in the current year. The first five industries in SO_2 emission include: electric power, steam and hot water production and supply industry, nonmetallic mineral product manufacturing industry, chemical feedstock and chemical product manufacturing industry, ferrous metal smelting & processing industry and nonferrous metal smelting & processing industry.

(17) COD discharge intensity per 10,000 Yuan industrial added value in heavy pollution industries: refers to the COD discharge intensity of 10,000Yuan industrial added value of the first 5 heavy pollution industries in COD emission in the current year. The first five industries in COD discharge include: papermaking and paper product industry, food processing industry, chemical feedstock and chemical product manufacturing industry, beverages manufacturing industry and textile industry.

(18) CO_2 emission reduction due to close-down of backward production capacities: refers to synergistic CO_2 emission reduction produced by closing down enterprises with backward production capacity. Calculation method is to convert the eliminated production capacity into energy consumption according to the list of eliminated backward production capacities in the Comprehensive Work Plan of Saving Energy and Diminishing Pollution issued by the State Council and then make an estimation by using the carbon

emission factor per unit product. Calculation result indicates that by the end of 2010, if the related measures in the "Comprehensive Work Plan of Saving Energy and Diminishing Pollution" can be accomplished as scheduled, emission of 2.4 million tons of SO_2 and 0.4 million tons of COD can be reduced through structural reduction and additionally, emission of 240 million tons of CO_2 can be reduced. If facility measures are considered, 149 million tons of CO_2 are added and 26 million tons of CO_2 reduced by management reduction are subtracted and then net reduction of CO_2 by the emission reduction measures is 117 million tons.

2.3.3 Determination of indicators' target value

For environmental performance assessment, determination of the policy target for all indicators is particularly important. Rational and effective policy target is the bridge to link the actual environmental performance reflected by all indicators with the expectation of policy regulation and control and also is the important parameter for standardized data processing, which has important impact on faithfully and fairly measuring the environmental performance level. For determination of all indicators target values, there are many trains of thoughts. Some can have the final target determined, some can only have phased target determined and others can only have the target of proper change determined. In this study, different methods are applied for different indicators:

Plan target value method: the target value determined in the 11th FYP for Environmental Protection is the main goal of pollution emission reduction work and the basis for assessing the effect of pollution emission reduction work. The target values of such indicators as COD and SO_2 emission amount, the proportion of air quality equal to or above Grade II over 292 days in major cities, proportion of water quality worse than Grade V in surface water monitored section (%), proportion of water quality better than Grade III in main water system monitored section (%), proportion of total investment in pollution treatment in GDP, quantity of eliminated water-related backward production capacity and quantity of eliminated air-related backward production capacity are determined in accordance with the "National Eleventh Five Year Plan for Environmental Protection".

Standard target value method: target value is determined in accordance with related national standards or requirements. For example, public satisfaction with urban environmental protection, COD discharge intensity of heavy pollution industries and SO_2 emission intensity of heavy pollution industries adopt the target values required in the "Construction Indicators of Ecological County, Municipality and Province (Revision)". Public satisfaction with urban environmental protection adopts the evaluation target value for ecological cities and the other two indicators adopt the evaluation target value for ecological provinces.

Theoretical (ideal) target value method: the theoretically or empirically attainable level is used as the target, e.g. annual average operation rate of industrial wastewater treatment facilities, comprehensive desulphurization efficiency of electric power industry and stable network connection proportion of on-line monitoring facilities in key national monitored enterprises (%).

Table 10: Indicators' Target Values and Weight

Comprehensive indicator	Specific indicators	Indicator No.	Weight	Target value	Remarks
Policy response	Proportion of total investment in pollution treatment in GDP (100,000,000 Yuan)	(1)		1.35%	11th FYP
	Removal rate of industrial sulfur dioxide (%)	(2)		100%	Theoretical value
	Municipal domestic wastewater treatment rate (%)	(3)		100%	Theoretical value
	Annual average operation rate of industrial wastewater treatment facilities (%)	(4)		100%	Theoretical value
	Annual average operation rate of treatment facilities in wastewater treatment plants (%)	(5)		100%	Theoretical value
	Comprehensive desulphurization efficiency of electric power industry (%)	(6)		100%	Theoretical value
	Eliminated quantity of backward production capacities (100,000,000Yuan)	(7)		14355	
	Stable network connection proportion of on-line monitoring facilities in key national monitored enterprises (%)	(8)		100%	Theoretical value
Environmental pressure	COD discharge (10,000t)	(9)		1270	11th FYP
	SO_2 emission (10,000t)	(10)		2295	11th FYP
Environmental state	Proportion of air quality equal to or above Grade II over 292 days in major cities (%)	(11)		75%	11th FYP
	Proportion of cities with acid rain occurrence among monitored cities (%)	(12)		100%	Theoretical value
	Proportion of water quality worse than Grade V in surface water monitored section (%)	(13)		<22%	11th FYP
	Proportion of water quality better than Grade III in main water system monitored sections (%)	(14)		>43%	11th FYP
Comprehensive impact	Public satisfaction with urban environmental protection (%)	(15)		90%	Evaluation indicator for ecological municipalities (revised)
	Economic loss due to atmospheric pollution (100,000,000 Yuan)	(16)		424.85	Green GDP accounting result
	SO_2 emission intensity per 10,000Yuan industrial added value in heavy pollution industries (kg/10,000 Yuan)	(17)		<6.0	Evaluation indicator for ecological provinces (revised)
	COD discharge intensity per 10,000Yuan industrial added value in heavy pollution industries (kg/10,000 Yuan)	(18)		<5.0	Evaluation indicator for ecological provinces (revised)
Global environment	CO_2 emission reduction due to close-down of backward production capacities (100,000,000t)	(19)		1.17	11th FYP

2.3.4 Data standardization method

Target value standardization method is used to convert indicator value into a standardized value between 0 and 100 by comparing the indicator value with target value.

$$Pi = \begin{cases} Xi/Ai & Xi < A \\ 1 & Xi > Ai \end{cases}$$

If the data value is greater, the better. (Equation 2-1)

$$Pi = \begin{cases} Ai/Xi & Xi > A \\ 1 & Xi < Ai \end{cases}$$

If the data value is smaller, the better. (Equation 2-2)

Where, P_i is standardized value of the indicator, X_i is original value of an indicator and Ai is the standard value of the indicator.

2.3.5 Determination of indicators weight

For any link of the DPSIR, it is obviously impossible to emphasize which one is more important. As part of a complete logic framework, each type of indicator is indispensable. Emission amount is both the result of driving force and the direct cause for environmental quality change. This applies to the other indicators. Therefore, in determining the assessment weight, the general Analytical Hierarchy Process or Expert Investigation Method is not used. In stead, all factors or various emission reduction effects are considered to be equally important, i.e. equal weight method is used as the indicator weighing basis and this is simpler and more direct. Of course, for policy response indicator and policy effect indicator, the sum of respective weights meets the conditions of equaling 1.

$$\sum_{i=1}^{n} W_i = 1$$

2.3.6 Calculation of performance indicators

After data standardization is finished, emission reduction performance indicator (EPPI) can be calculated by target values and weights of all indicators. This indicator is a value between 0 and 100 and higher indicator value means overall emission reduction effect is closer to the expected target. The specific calculation equation is as follows:

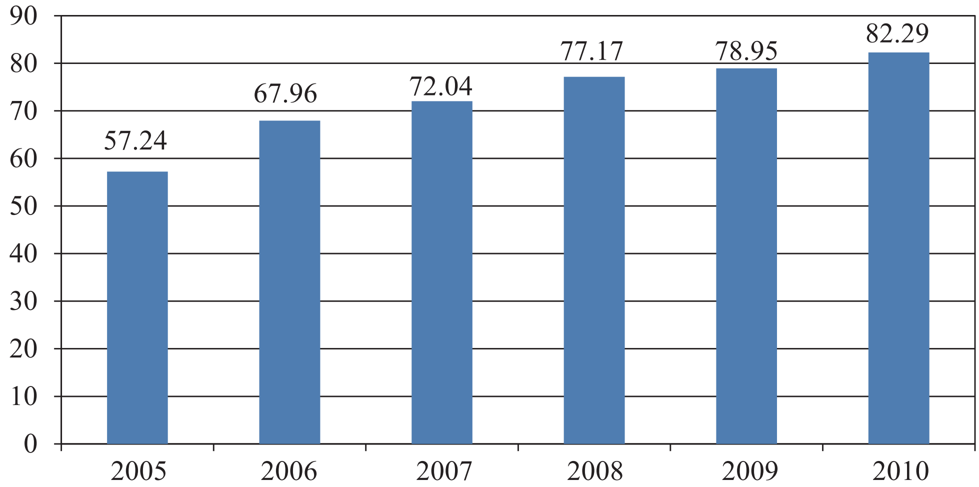
$$EPPI = \sum_{i=1}^{n} P_i W_i$$

3. ANALYSIS OF ASSESSMENT RESULTS

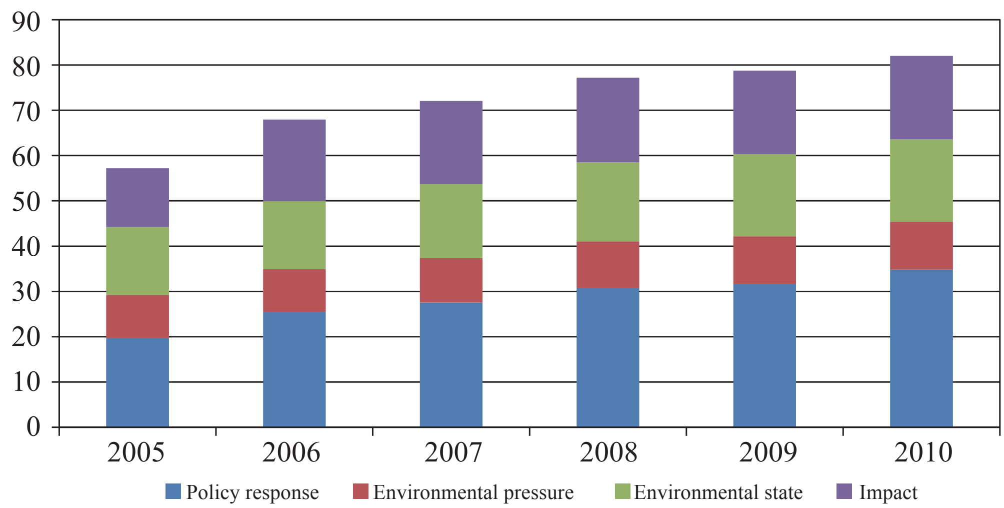
3.1 Overall review at national level

According to the calculation results of emission reduction performance indicators, in 2006-2010, environmental governance level and effect in China was improved significantly with the implementation of total emission reduction policies and emission performance indicator increased from 57.24 in 2005 to 82.29 in 2010, up 43.76%.

■ **Figure 21: Calculation Result of Pollution Emission Reduction Performance Indicators**



■ **Figure 22: Composition of Pollution Emission Reduction Performance Indicators**



In terms of compositions of the indicators, policy response indicator has the largest contribution to emission reduction performance indicator. It increased from 34% in 2005 to 42%, indicating that the most significant effect of emission reduction policy is that it promoted the pollution treatment facility construction and management operation efficiency.

To further judge the performance of different policies, all the 19 indicators are grouped by indicator attribute, including 17 positive indicators (larger value performs better) and 2 inverse indicators (smaller value performs better).

By using the emission reduction target 10% in the 11th FYP period and the comprehensive growth rate 17.41% in 2006-2010 as parameters, the 16 indicators are divided into the following five groups:

Group 1 (growth rate>100%)

Indicators	2006	2010	Growth rate
Stable network connection proportion of on-line monitoring facilities in key national monitored enterprises (%)	1.69	4.6	170%
Comprehensive desulphurization efficiency of electric power industry (%)	1.39	3.62	160%

Group 2 (growth rate 17.41%-100%)

Indicators	2006	2010	Growth rate
Proportion of air quality equal to or above Grade II over 292 days in major cities (%)	3.12	5.2	66%
Removal rate of industrial sulfur dioxide (%)	2.07	3.39	64%
Municipal domestic wastewater treatment rate (%)	3.32	5.3	60%
Proportion of water quality worse than Grade V in surface water monitored sections (%)	4.16	5	-20%

Group 3 (growth rate 10%-17.41%)

Indicators	2006	2010	Growth rate
SO_2 emission intensity per 10,000Yuan industrial added value in heavy pollution industries (kg/10,000Yuan)	4.61	5.3	15%
SO_2 emission (10,000t)	4.7	5.3	13%
COD discharge (10,000t)	4.71	5.3	12%
Proportion of investment in environmental pollution treatment in GDP (%)	4.79	5.3	10%

Group 4 (growth rate<10%)

Indicators	2006	2010	Growth rate
Proportion of water quality better than Grade III in main water system monitored sections (%)	4.93	5.3	8%
Proportion of cities with acid rain occurrence among monitored cities (%)	2.86	2.67	-7%
Public satisfaction with urban environmental protection (%)	4.25	4.55	7%
Annual average operation rate of treatment facilities in wastewater treatment plants (%)	3.63	3.83	6%
Annual average operation rate of industrial wastewater treatment facilities (%)	3.29	3.45	5%

Group 5 (growth rate<10%)

Indicators	2006	2010	Growth rate
Economic loss due to atmospheric pollution (100,000,000 Yuan)	2.96	2.4	-23.33%

The two indicators whose growth rate is higher than 100% in 11th FYP period are response indicators. Comprehensive desulphurization efficiency (SO_2 removal rate) of electric power industry (%) increased from 27% to 69% and stable network connection proportion of on-line monitoring facilities in key national monitored enterprises (%) increased from 32% to 87%. Increase of comprehensive desulphurization efficiency of electric power industry is directly related to the preferential policy for desulphurization electricity price and enterprises' pollution treatment costs can be compensated by the national preference of desulphurization electricity price. Therefore, the implementation of desulphurization electricity price policy has greatly enhanced enterprises' enthusiasm for pollution control.

The four indicators (two response indicators and two state indicators) in Group 2 also performed well in the 11th FYP period and growth rate of individual indicators exceeded the average level of the comprehensive performance of 11th FYP indicators. With management reduction measures taken, SO_2 removal rate rose from 39% to 64%, slightly lower than SO_2 removal rate of electric power industry. Proportion of air quality equal to/or above Grade II over 292 days in major cities rose from 44% in 2006 to 73%, indicating that air quality of major cities in China takes a turn for the better. At the same time, municipal domestic wastewater treatment rate increased from 44% to 73%, which is a long term progress and reached and exceeded the target value in the 11th Five Year Plan. Proportion of water quality worse than Grade V in surface water monitored sections dropped from 28% to 16%, indicating the effect of COD discharge reduction.

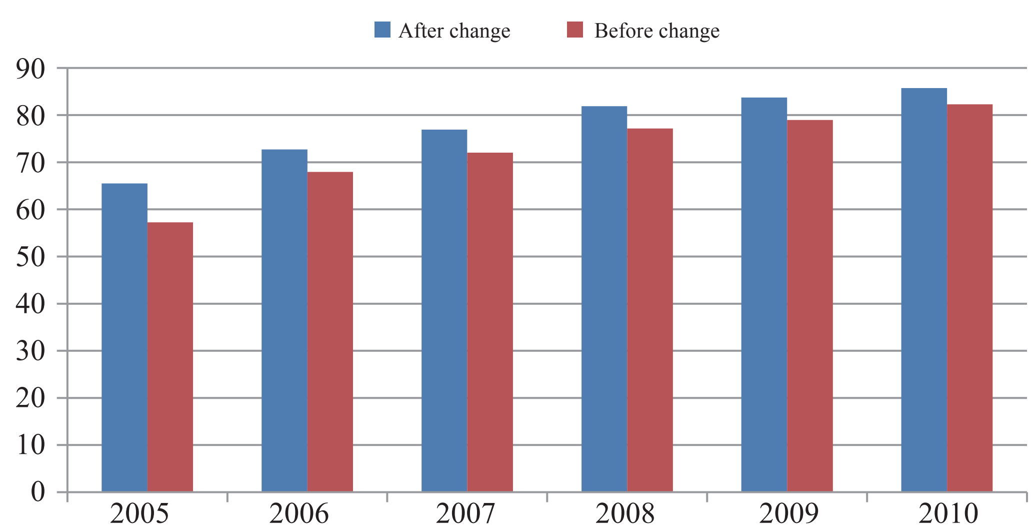
Group 3 is a group of indicators whose growth rate is between 10% (pollutant emission reduction target value) and 17% (11th FYP period average growth rate). Compared with the previous two groups, this group did not perform very well and was lower than average growth rate. But a common feature of this group is that they all reached the planned target value or ideal target value in 2010. SO_2 emission intensity per 10,000 Yuan industrial added value in heavy pollution industries began to be lower than the 11th FYP target since 2007 and thus its actual growth rate was much higher than relative growth rate. The two major indicators of SO_2 emission and COD discharge were much higher than 11th FYP targets whether in static reduction or actual reduction in 2005. Proportion of investment in environmental pollution treatment in GDP did not perform well and the main cause is that GDP growth speed in the 11th FYP period was higher than growth speed of environmental protection investment. In fact, all relative indicators linked with GDP have this problem.

Of Group 4, proportion of water quality better than Grade III in main water system monitored sections increased from 40% to 60% and absolute increase rate reached 50%. But in the standardized indicator system, the growth rate of this indicator was only 7%. The main reason for this is that plan target value is on the low side. Proportion of cities with acid rain occurrence among monitored cities was not changed markedly in the 11th FYP period, indicating that merely controlling SO_2 can not reduce acid rain frequency.

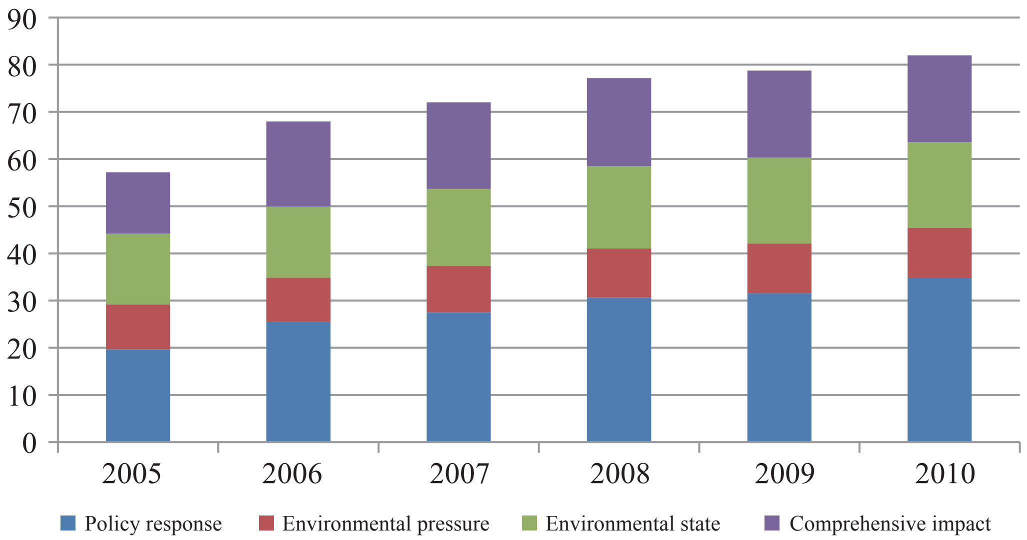
3.2 Sensitivity analysis

The equal weight in this study is to use equal weight for the three levels of 19 indicators, which means that these 19 indicators are considered to be equally important for the overall emission reduction performance indicator. Another equal weight method is that the secondary indicators, i.e. policy response, emission pressure, environmental state and comprehensive impact, are given equal weight by 25 points and all tertiary indicators are given equal weight on this basis. The simulation results are shown below:

Figure 23: Performance indicators of different equal weight methods



■ **Figure 24: Indicator compositions after change of equal weight distribution method**



It is seen that after weight distribution method is adjusted, the annual gradual increase trend of emission reduction performance indicators is not changed but all post-adjustment indicators values are higher than the pre-adjustment indicator values, indicating that the second equal weight method relatively weakens the impact of the tertiary indicators quantity on performance indicators calculation.

In terms of adjusted indicators structure, changing the equal weight method actually adjusts indicator structure. After adjustment, the four major types of indicators are less affected by their respective tertiary indicators quantity and the indicators originally in a small quantity such as emission pressure will get a much higher score.

4. CONCLUSION AND POLICY RECOMMENDATIONS

Remarkable achievements have been made by China's pollution reduction policies since the "11th Five-Year" period, surpassing its goal of reducing both COD and SO_2 by 10% from 2005. Furthermore, the five years' effort has led to considerable improvement in both the nation's ability to control pollution and the government's ability of, and efficiency in, environmental management. However, the rapid economic growth, and huge economic aggregate and population base have also prevented the environmental problems and environmental risks from being fully alleviated.

Our study established an approach for evaluating the performance of China's pollution reduction policies by reference to UNEP and DPSIR frameworks, and selected pilot provinces for evaluation. Results from the evaluation of these pilot provinces show significant increase in reduction performance relative to the "11th Five-Year" period, despite the differential in the performance indicators scores of different subjects. This is particularly true with respect to the environmental control ability and government environmental regulation ability. However, we have to note that the applicability of the reduction performance evaluation approaches still needs further verification and amendment to address the different economic development levels, the different environmental capacities and the essential environmental concerns among the different pilot provinces.

To further promote the application of the reduction performance evaluation approaches and better suit them to the pollution reduction efforts in and after the "11th Five-Year" period, the following are conclusions of the project, with regard to the application of the approaches and our policy recommendations.

Recommendations on Applying Methods that Evaluate Reduction Performance

The DPSIR-based reduction performance evaluation approach reveals the interaction between environmental concerns and human activities from the generation and impact of, and government response to, environmental concerns. It helps us understand how environmental concerns come about and evolve, and also helps decision makers to address different processes involved in the evolvement of environmental concerns when designing policies and provides more selective environmental policies.

However, given the current foundation of China, establishing a comprehensive DPSIR-based evaluation indicators system is still inoperable. Therefore, the simplified evaluation indicators system presented herein is recommended for the initial stage before a comprehensive evaluation indicators system is eventually applied with the advancement of and science and technological methodologies and the improvement of the statistical indicators system.

For the application of a given approach, the evaluation framework established so far is only an attempt that is quite a distance from management application. Further improvements are recommended below:

Firstly, when selecting an indicators system, it is recommendable that the indicators framework be amended and improved by further identifying the current status of fundamental statistical data, in particular changes in the key content and measures of pollution reduction. Any amendment shall address communication and interconnection between management departments at different levels and ensure that the indicators system is established to reflect every aspect of the practical reduction effort.

Secondly, when selecting an indicators weight and a standardization method, it is important that scientific and regular evaluation methods and procedures are provided after further comparison among different weight selection methods and standardization methods.

Thirdly, an evaluation method system addressing different levels should be established, since a universally viable evaluation method system is evidently unpractical in the context of China that is vast in territory, and where natural endowments, environmental capacity and economic-social development foundation vary significantly and lead to different behaviors in the reduction policy performances among different regions and different administrative levels. These differences should be addressed by any indicators system established.

Fifthly, based on all these considerations, we recommend research be performed in cooperation with UNEP on establishing a state – provincial – municipal – enterprise multi-level reduction policy performance evaluation method system, amend and improve the existing method framework, and promote the application of performance evaluation and performance management tools in the environmental protection sector of China through pilot demonstration.

Recommendations on Improving the Execution of Pollutant Reduction Policies

From our evaluation of the pollution reduction policy performance of the state and in Jilin, Shanghai, Xi'an, and Linyi during the "11th Five-Year" period, in addition to meeting and surpassing the total pollutant control goal defined in the outline of the national economic and social development plan for the "11th Five-Year" period, notable achievements have also been made in the implementation of the reduction policies, the most noteworthy being: a) much better understanding of environmental protection and pollution reduction efforts in governments, enterprises and society; b) considerable improvement in the nation's pollution control ability and the government's environmental regulation ability; c) an institutional mechanism that effectively pushes forward reduction efforts, including the target responsibility system and the quantitative assessment mechanism that supports it, which guaranteed the fulfillment of reduction targets, policies, and measures; 4) effectively reinforced construction of reduction monitoring, statistics, and assessment capability.

The remarkable achievements in the pollution reduction efforts during the "11th Five-Year" period are attributable to:

Firstly, the high recognition by the central party committee and the state council, a target responsibility system centering around the targets and a quantitative assessment mechanism that supports it, which were the essential guarantee for the remarkable achievements in the pollution reduction efforts and the successful implementation of the reduction measures.

Secondly, a series of institutional and technical provisions that defines the reduction targets to each specific aspect.

At the state level, the state council issued the Notice of the State Council on Issuing the Comprehensive Work Plan for Energy Conservation and Pollution Reduction (GF [2007] 15) and the Notice of the State Council on Approving and Forwarding the Implementation Plan and Methods for Energy Conservation and Pollution Reduction Statistics, Monitoring and Assessment (GF [2007] 36. The Ministry of Environmental Protection issued the Measures for Auditing the Reduction in the Total Discharge of Main Pollutants for the "11th Five-Year" Period, the Detailed Rules on Accounting the Reduction in the Total Discharge of Main Pollutants, and the Measures for Accounting the Supervisory Coefficient of the Reduction in the Total Discharge of Main Pollutants as measures to regulate the auditing and accounting of pollution reduction.

Thirdly, general availability of guarantee policies, in particular, environmental economic policies. More rigid emission standards were implemented for key industries including papermaking, leather, and chemical industries. A desulfurization power tariff policy was enacted and rigidly executed. SO_2 emission was charged twice as much. Municipal sewage treatment was charged 0.8 yuan/t. Funds for constructing urban sewage treatment system were supplemented or subsidized under "supplement by reward" or "control by reward" fund programs along key drainage basins and in the central-west regions.

Fourthly, rigid assessment and reward or punishment measures. During the "11th Five-Year" period, 111 units having problems with pollution reduction were either publicly criticized or listed for supervision. Six regional-level cities and four business groups were placed under regional restriction for approval of new projects. Eight provincial-level governments, 250 advanced collectives and 250 advanced individuals were publicly commended by the state council.

Fifthly, substantial improvement in the environmental supervision ability; increase in the percentage of environmental input in GDP from 0.5% at the end of the "10th Five-Year" period to around 1% at the end of the "11th Five-Year" period; initial effect in the construction of the reduction monitoring system, statistical system, and assessment system; and cultivation of a reduction workforce of professional competence.

Recommendation on Reduction Policies

Based on the performance evaluation at the state level and recommendations on the pilot provinces, the following measures are recommended for the next step of reduction efforts:

1. Highlight the role of economic means in promoting structural reduction. Engineering reduction has limited potential during the "12th Five-Year" period, and structural reduction involves cancellation of outdated capacities and channelization of surplus capacities. With respect to canceling outdated capacities, the environmental responsibility of local governments should be intensified and local governments should be made the subject of canceling outdated capacities through an institutional mechanism, and effective legislative and institutional design. Besides, supporting subsidy policies should be established to resolve social conflicts through fiscal or financial means, taxation and direct subsidies. In channelizing surplus capacities, local governments should reinforce supervision and prevent pollution transfer.

2. Intensify the environmental responsibility of enterprises, which are the subject of pollution reduction, and change the present practice of making local environmental departments the subject of pollution reduction. First, the environmental responsibility of enterprises should be legislatively identified so that not only enterprises themselves are required to control environmental pollution with all their assets as credit, but interested departments, especially banks, are also held jointly and severally liable. Next, environmental information of enterprises should be disclosed and published. We recommend that a mandatory open system be exercised and enterprises be required to make public their pollution emission information independently and receive social supervision. Finally, online monitoring management of enterprises at the pollution emission outlets should be regulated, and an open information system for online monitoring data be implemented to ensure the normal operation of pollution control facilities and the accuracy of monitoring data.

3. Strengthen the construction of the reduction statistical capability, which is the basis for implementing any reduction plan as well as the fundamental work for evaluating reduction performance. We recommend improving the existing reduction statistical system, identifying the responsibility of different subjects including enterprises and environmental departments during the acquisition, reporting, summarizing and managing statistical data, and improving the quality of statistical data. It is also important to intensify the application of statistical data, analyze, conclude, and summarize problems detected during the implementation of the reduction plan, and enhance the supporting role of statistics for pollution reduction.

4. Employ more effort in promotion and further improve public understanding of and support for pollution reduction activities. The promotion should not only focus on public awareness of environmental concerns, but more importantly, show the public how much their behaviors are related to environmental concerns. These may be achieved by producing books, audio/video products, or pamphlets to strengthen promotion of pollution reduction efforts and increase the public understanding of and support for pollution reduction strategies and measures, and involving social forces in the reduction supervision processes to achieve better implementation of reduction policies.

5. Build up a reduction policy framework in the consumer sector. The permanent cure of pollution control is by adjusting the consumer behavior of people themselves, whereas the changed consumer demand in turn promotes the adjustment in enterprises' production structure. Transformation of the public consumption pattern and structure should be enhanced principally through promotion and education, and by advocating and demonstrating the concept of green consumption. This is the permanent cure for pollution prevention and control.

REFERENCE

1 UNEP, Integrated Assessment and Planning for Sustainable Development Guidelines for pilot projects, Version 1, March 2004 http://www.unep.ch/etb/Topics/inteAsse/IAPGuidelinesPilotProjectsEN.pdf

2 US EPA, Guidelines for Ecological Risk Assessment, Published on May 1998, Risk Assessment Forum, Washington DC http://www.epa.gov/raf/publications/pdfs/ECOTXTBX.PDF

3 European Environment Agency, Environmental Indicators: Typology and Use in Reporting, Copenhagen, August 2003 http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Workshops/FEEM/Indicators/EEA_Working_paper_DPSIR.pdf

4 European Environment Agency, Environmental Indicators: Typology and Overview, Copenhagen, Technical Report No 25/1999 http://www.eea.europa.eu/publications/TEC25

5 OECD, OECD Key environmental indicators 2008, 2008, Paris France, OECD Environnent Directorat http://www.oecd.org/dataoecd/20/40/37551205.pdf

6 GMS Environment Operations Center, Environmental Performance Assessment, Bangkok Thailand. (Accessed on 2011) http://www.gms-eoc.org/CEP/Comp3/docs/EPA_Synthesis_Report.pdf

7 OECD, Environmental Performance Review of China: Lessons Learned from Yunnan Province Experience, Kunming, 10 August, 2005 http://www.oecd.org/dataoecd/62/33/35414971.pdf

8 European Environment Agency, EEA core set of indicators - Guide, Copenhagen, Technical report No 1/2005 http://www.eea.europa.eu/publications/technical_report_2005_1

9 J. Andrew Kell, An Overview of the RAINS Model Environmental Research Centre Report, Environmental Protection Agency, Ireland, 2006 http://www.epa.ie/downloads/pubs/research/air/epa_overview_of_rains_model_erc4.pdf

10 GMS Environment Operations Center, Environmental Performance Assessment, Bangkok Thailand. http://www.gms-eoc.org/CEP/Comp3/docs/EPA_Synthesis_Report.pdf

11 Ministry of Agriculture Food & Rural Affairs, Does Manure Have a Place in the Sulfur Debate? Christine Brown (Nutrient Management Field Crop Lead/OMAFRA), Ontario, Jun, 2006 http://www.omafra.gov.on.ca/english/crops/field/news/croptalk/2006/ct_0606a2.htm

12 International Institute for Applied Systems Analysis (IIASA) GAINS Asia Scenarios For Cost-Effective Control Of Air Pollution and Greenhouses Gases In China. Laxenburg, Austria, November 2008

Chinese Academy for Environmental Planning

8 Dayangfang, BeiYuan Road, Chaoyang District, Beijing 100012, China

Editor in chief: Prof. WANG Jinnan

President, Chinese Academy for Environmental Planning

Contact person: Mr. ZHANG Hongyu

Tel: 86-10-84917585

Fax: 86-10-84918581

E-mail: zhanghongyu@caep.org.cn

Web: www.caep.org.cn