Air Pollution Control Strategy in China

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Characteristics of Energy Utilization

Issues and Challenges of Air Pollution Control

Air Pollution Control Target

Strategy to Achieve Better Air Quality
Energy Utilization—still increasing rapidly

Energy consumption (100 million tce)
GDP (1000 billion RMB)
Populations (100 million)


Energy use for 2006 24.6; 2007 26.6; 2008 28.5
(in 100 million tce)
Energy Utilization—comparison with other countries

Energy Utilization—much depending on coal

Energy Consumption and Structure in China (1990-2005)

- Coal-based energy structure
Trade of petroleum (in million ton):

<table>
<thead>
<tr>
<th>Year</th>
<th>Import</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>211.4</td>
<td>26.7</td>
</tr>
<tr>
<td>2008</td>
<td>178.9</td>
<td>21.2</td>
</tr>
</tbody>
</table>
Energy use per capita

- China’s energy consumption per capita in 2007 was about 18% of that in US

- China’s oil consumption per capita in 2007 was about 10% of that in US
How will we develop our economy in future?
Energy Utilization—change in efficiency

Trends of Thermal Power Plants Electricity Supply
Coal Consumption in China (1989-2007)

Gradually reduced
Gradually reduced Trends of Steel Sector Coal Consumption rate in China (1991-2006)
Energy Utilization—high energy intensity

In 2006, the energy intensity (China) was 2.82 times of the world level.

About the Energy Efficiency in China

- Energy consumption of China: 18% of the world
- Support a largest country by products, but not a largest country by value
  - the outputs of more than 100 products rank number one in the world
    - the steel output = the summation of OECD
    - The cement output = the summation of all other country in the world
- Support the living and development of 1.3 billions people
Characteristics of Energy Utilization

Issues and Challenges of Air Pollution Control

Air Pollution Control Target

Strategy to Achieve Better Air Quality
Control of particulate matter emission
Control of SO$_2$ Emission
Control of SO₂ Emission – power sector

Coal Consumption by power plant
Capacity with FGD

二氧化硫排放量增长指数

电煤耗量

年份

NOX Emissions

NOx emissions, kt

- Year: 1990
- Emissions: 8000 kt

- Year: 1991
- Emissions: 9000 kt

- Year: 1992
- Emissions: 10000 kt

- Year: 1993
- Emissions: 11000 kt

- Year: 1994
- Emissions: 12000 kt

- Year: 1995
- Emissions: 13000 kt

- Year: 1996
- Emissions: 14000 kt

- Year: 1997
- Emissions: 15000 kt

- Year: 1998
- Emissions: 16000 kt

- Year: 2000
- Emissions: 17000 kt

- Year: 2001
- Emissions: 18000 kt

- Year: 2002
- Emissions: 19000 kt

- Year: 2003
- Emissions: 20000 kt

- Year: 2004
- Emissions: 21000 kt

- Year: 2005
- Emissions: 22000 kt

- Year: 2006
- Emissions: 23000 kt
76.8% among 519 cities the air quality were in Grade II or better
Air quality in heavily polluted city was improved - Chongqing Case

Trends of concentrations for PM10 and SO2 in the urban area
Air quality in heavily polluted city was improved - Beijing Case

<table>
<thead>
<tr>
<th>Year</th>
<th>SO₂</th>
<th>NO₂</th>
<th>CO</th>
<th>PM₁₀</th>
<th>NAAQS II days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>0.064</td>
<td>0.071</td>
<td>2.6</td>
<td>0.165</td>
<td>185</td>
</tr>
<tr>
<td>2002</td>
<td>0.067</td>
<td>0.076</td>
<td>2.5</td>
<td>0.166</td>
<td>203</td>
</tr>
<tr>
<td>2003</td>
<td>0.061</td>
<td>0.072</td>
<td>2.4</td>
<td>0.141</td>
<td>224</td>
</tr>
<tr>
<td>2004</td>
<td>0.055</td>
<td>0.071</td>
<td>2.2</td>
<td>0.149</td>
<td>229</td>
</tr>
<tr>
<td>2005</td>
<td>0.05</td>
<td>0.066</td>
<td>2.0</td>
<td>0.142</td>
<td>234</td>
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<tr>
<td>2006</td>
<td>0.053</td>
<td>0.066</td>
<td>2.1</td>
<td>0.161</td>
<td>241</td>
</tr>
<tr>
<td>2007</td>
<td>0.047</td>
<td>0.066</td>
<td>2.0</td>
<td>0.148</td>
<td>246</td>
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<tr>
<td>2008</td>
<td>0.036</td>
<td>0.049</td>
<td>1.44</td>
<td>0.122</td>
<td>274</td>
</tr>
<tr>
<td>Changes</td>
<td>-43.8%</td>
<td>-31.0%</td>
<td>-44.6%</td>
<td>-26.1%</td>
<td>48.1%</td>
</tr>
</tbody>
</table>
Simulation of CMAQ model indicated that large regions in China were covered with high PM$_{2.5}$ concentrations.
PM$_{2.5}$ Pollution and Regional Haze

Visibility in east China decreased 10km during 1957—2005, with a decreasing rate of 0.24 km/yr.
NO$_2$ and ozone pollution
Acid Deposition

Acid rain is still a challengeable problem

- Areas with precipitation pH < 5.0 account for about 30% ~ 40%
- Heavy polluted areas with a pH < 4.5 increased
- Some northern cities observed acid deposition
Frequency of acid deposition in Yangtze River Delta

- Shanghai
- Zhejiang
- Jiangsu
- Yangtze RD

Frequency of acid rain, %

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
The next 15 years is the critical period for China to complete the capital-intensive industrialization and the peak time of China’s population.

*Reference: World Outlook 2007*
Challenges of future air pollutant emissions

**SO₂**  
- 14% increase (2020 vs 2005)  
- 10% decrease (2010 vs 2005)

**NOₓ**  
- 36% increase (2020 vs 2005)  
- 13% increase (2020 vs 2005)

**PM₂.₅**  
- 6% decrease (2020 vs 2005)  
- 32% decrease (2020 vs 2005)
Sulfur dioxides and nitrogen dioxides in 2020

**Annually Mean of the SO2 and NO2 surface concentration (ug/m³)**

- **SO2**
  - 2005BASE
  - REF0-BASE
  - PC2-BASE

- **NO2**
  - Annually Mean of NO2 (CMAQ) for each base year.

- **SO2 concentration will be much improved under PC[2]**

- **NOx pollution even get worse under both scenarios**
PM concentration increase by 5% under REF scenario, and decrease by 12% ~ 21% under PC2.
Sulfate and nitrate in PM2.5 in 2020

Annually Mean of the Sulfate and Nitrate surface concentration (µg/m³)

- Nitrate increases 23%~53% under REF0 and 10%~37% under PC2.
- The percentage of nitrate in PM has been increased as well, from 16% in 2005 to 20% in 2020.
Ground ozone concentration in 2020

Surface concentration during summer time (Daily maximum, ug/m3)

- Because of the rising of NOx emission, daily maximum concentration of ozone in summer in most area increase over 5% under REF0 and 2% under PC2.
# Wet deposition in 2020

## Annually Wet deposition of Sulfate and Nitrate (kg/ha)

### 2005BASE

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<thead>
<tr>
<th>region</th>
<th>WSO4 Dep.</th>
<th>WNO3 Dep.</th>
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</thead>
<tbody>
<tr>
<td>NCP</td>
<td>REF0 1</td>
<td>PC2 -20</td>
</tr>
<tr>
<td>YRD</td>
<td>REF0 29</td>
<td>PC2 7</td>
</tr>
<tr>
<td>PRD</td>
<td>REF0 2</td>
<td>PC2 -26</td>
</tr>
<tr>
<td>SWB</td>
<td>REF0 38</td>
<td>PC2 8</td>
</tr>
<tr>
<td>TOT</td>
<td>REF0 8</td>
<td>PC2 32</td>
</tr>
</tbody>
</table>

### Change of nitrate and sulfate wet deposition (annual mean, %)

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<tr>
<th>region</th>
<th>NCP</th>
<th>YRD</th>
<th>PRD</th>
<th>SWB</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSO4</td>
<td>REF0</td>
<td>PC2</td>
<td>REF0</td>
<td>PC2</td>
<td>REF0</td>
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<tr>
<td>WNO3</td>
<td>59</td>
<td>21</td>
<td>53</td>
<td>19</td>
<td>64</td>
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</table>
Challenges of GHG emissions

The pressure of climate change will rise

1980

China 8%

Europe 25%

Former USSR 17%

Brazil 1%

India 2%

Japan 5%

Others 15%

United States 26%

2004

China 17%

Europe 17%

Former USSR 9%

Brazil 1%

Mexico 1%

India 4%

Japan 5%

Others 24%

United States 22%

China has developed into the second largest CO₂ emitter and one of fastest growing source in the world today.

18,333 Mt of CO₂

27,044 Mt of CO₂

Note: Carbon dioxide emissions in the two figures are emissions from consumption and flaring of fossil fuels.
Challenges of GHG emissions

CDIAC, 2007
Characteristics of Energy Utilization

Issues and Challenges of Air Pollution Control

Air Pollution Control Target

Strategy to Achieve Better Air Quality
Through 2050, to protect public health and ecological safety, air quality all over the country meet the national ambient air quality standard by initiating and implementing national clean air action, and that in most cities achieve the WHO ambient air quality guideline values.

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<tr>
<th></th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>O$_3$</th>
<th>NO$_2$</th>
<th>SO$_2$</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>annual</td>
<td>24h</td>
<td>8h</td>
<td>annual</td>
<td>hourly</td>
</tr>
<tr>
<td>Phase I</td>
<td>35</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Phase II</td>
<td>25</td>
<td>100</td>
<td>160</td>
<td></td>
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<tr>
<td>Phase III</td>
<td>15</td>
<td>75</td>
<td></td>
<td></td>
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<tr>
<td>Directive</td>
<td><strong>10</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
<td><strong>40</strong></td>
<td><strong>200</strong></td>
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</table>
## Air Pollution Control Targets

<table>
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<tr>
<th>Urban air quality</th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over 95% of the cities reach the national class II ambient air quality standard; Developed areas achieve the phase II target value of WHO guideline</td>
<td>Over 80% of the cities achieve the phase III target value of WHO guideline</td>
<td>Most cities in China meet WHO ambient air quality guideline</td>
</tr>
</tbody>
</table>
### Air Pollution Control Targets

**Emission reduction targets based on 2005 levels**

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2</td>
<td>30%</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>NOx</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>PM10</td>
<td>20%</td>
<td>30%</td>
<td>50%</td>
</tr>
<tr>
<td>VOCs</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
</tr>
</tbody>
</table>

![Bar chart showing emission reduction targets for SO2, NOx, PM10, and VOCs across 2005, 2020, 2030, and 2050.]
Outline

- Characteristics of Energy Utilization
- Issues and Challenges of Air Pollution Control
- Air Pollution Control Target
- Strategy to Achieve Better Air Quality
① Whole process control strategy—change of development patterns

- Implement strict environmental regulation to promote economic structure transition and clean production
- Speed up application of advanced technologies and abandon traditional, heavy-polluted development patterns
- Control air pollution from of whole production process, including clean energy and renewable energy utilization, energy saving, technology improvement, end-of-pipe control, supervision and management
Air Pollution Control Strategies

② Multi-pollutant co-benefit control strategy

- Management of Energy
  - Energy Efficiency
  - Cleaner Technologies
  - Renewable Energy

- Management of Air Quality
  - Multi-pollutant control

- Mitigation of Climate Change

- Transportation
  - Sustainable Urban Transport
  - Transport Demand Management
  - Clean Vehicles

SO2
NOx
VOCs
NH3
PM
CO

Regional acid rain
Regional photochemical pollution
Regional fine PM pollution
Non-CO2 GHGs
③ Integrated control strategy based on environmental impact

- Actualize Cap and Trade program for important industries

Power plant  Cement plant  Chemical plant  Steel plant

- 45% of SO$_2$ emissions come from power industry, and 9% from metallurgy industry, 7% from cement industry.

- Keeping industry development without increase of emission.

- Adjust the industry structure and actualize pollution emission license.
Air Pollution Control Strategies

③ Environmental impact based integrated control strategy

- Actualize Cap and Trade program for important industries
- Emphasize vehicle pollution control in urban areas
- Constitute emission control regulations and standards for other area sources
Regional air quality management strategy

- Establish regional air quality management coordination systems and institutions in developed city-clusters such as Beijing and its surrounding areas, Yangtze River Delta and Pearl River
Implement National Clean Air Action

1. develop national air pollution control plan

2. carry out systemic real-time air quality monitoring,

3. study technologies and methodologies on emission inventory,

4. air quality modeling and policy making,

5. consummate air pollution control regulations and standards, and

6. establish regional and urban air quality management system.

7. Control the total coal consumption in heavy polluted areas,

8. Enhance the vehicle pollution control in mega-cities
Measures to reduce the emissions

1. Apply clean coal technologies, optimize energy structure and improve energy efficiency
2. Enhance vehicle pollution control
3. Reinforce SO2 emission control
4. Control NOx and VOCs emissions
5. Strengthen primary particulate emission control
6. Control ozone and secondary PM
1. Measures on Energy Use

① Minimize national total energy consumption

A dual strategy is needed to solve the energy security and air pollution

Source: Li Zheng, Tsinghua Univ.
1. Measures on Energy Use

② Adjust energy structure and increase the proportion of clean energy,

By 2020

➢ renewable energy may account for 15% of total energy

By 2030

➢ Coal account less than 50% of total energy consumption
➢ Coal end-use account for less than 50% of total coal use
➢ Coal-fired power plants account for less than 60% of total electricity
1. Measures on Energy Use

③ Limit the total coal consumption in severe air pollution regions

<table>
<thead>
<tr>
<th></th>
<th>Installed capacity, GW</th>
<th>Capacity per capita, kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>110</td>
<td>1.3</td>
</tr>
<tr>
<td>UK</td>
<td>80</td>
<td>1.2</td>
</tr>
<tr>
<td>Guangdong</td>
<td>70</td>
<td>0.9</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>54</td>
<td>1.0</td>
</tr>
<tr>
<td>Shanghai</td>
<td>25</td>
<td>1.5</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>50</td>
<td>0.8</td>
</tr>
<tr>
<td>Shandong</td>
<td>75</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Installed capacity in some areas are at same level of that in developed countries
1. Measures on Energy Use

④ Develop and promote clean coal technologies
⑤ Improve energy efficiency

<table>
<thead>
<tr>
<th>Sector</th>
<th>Domestic Energy Efficiency</th>
<th>International Advanced Energy Efficiency</th>
<th>Energy Saving Potential</th>
<th>Average Saving Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-fired generation</td>
<td>Efficiency 33.2%</td>
<td>Japan 40.1%</td>
<td>17%</td>
<td>17</td>
</tr>
<tr>
<td>Electric generation</td>
<td>8% used by generation</td>
<td>Japan 6% used by generation</td>
<td>25%</td>
<td>25</td>
</tr>
<tr>
<td>Oil refining</td>
<td>14.3 kgoe/t</td>
<td>Japan 8.9 kgoe/t</td>
<td>38%</td>
<td>44</td>
</tr>
<tr>
<td>Coal production</td>
<td>13.6 toe/1,000 tons</td>
<td>US 1.24 toe/1,000 tons</td>
<td>82%</td>
<td>25</td>
</tr>
<tr>
<td>Coke oven gas</td>
<td>Recycled heat percentage 29%</td>
<td>Japan 52%</td>
<td>23%</td>
<td>22</td>
</tr>
<tr>
<td>Coking</td>
<td>196 kgoe/t</td>
<td>Japan 161 kgoe/t</td>
<td>18%</td>
<td>26</td>
</tr>
<tr>
<td>Crude steel</td>
<td>781 kgoe/t</td>
<td>Japan 658 kgoe/t</td>
<td>16%</td>
<td>25</td>
</tr>
<tr>
<td>Ammonia</td>
<td>970 kgoe/t</td>
<td>International 664 kgoe/t</td>
<td>24%</td>
<td>26</td>
</tr>
<tr>
<td>Ethylene</td>
<td>784 kgoe/t</td>
<td>Japan 500 kgoe/t</td>
<td>36%</td>
<td>25</td>
</tr>
<tr>
<td>Cement</td>
<td>171 kgoe/t</td>
<td>Japan 121 kgoe/t</td>
<td>29%</td>
<td>26</td>
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<tr>
<td>Electrolytic aluminium</td>
<td>14.3 MWh/t</td>
<td>International 13.0 MWh/t</td>
<td>9%</td>
<td>29</td>
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<tr>
<td>Alumina</td>
<td>970 kgoe/t</td>
<td>International 454 kgoe/t</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>Heat and hot water</td>
<td>Average efficiency 25%</td>
<td>Targets 35%</td>
<td>29%</td>
<td>29</td>
</tr>
<tr>
<td>Gasoline vehicles</td>
<td>10.8 km/L</td>
<td>Japan 13.5 km/L</td>
<td>20%</td>
<td>20</td>
</tr>
</tbody>
</table>
1. Measures on Energy Use

- **Energy saving: building**
  - building energy consumption model
  - energy estimation for commercial buildings
  - energy label system for residential buildings
  - energy label system for home appliances

- **Energy saving: transportation**
  - Evaluate the effect of advanced technologies, including alternative fuels
  - Evaluate the effect of transportation system optimizing
2. Enhance vehicle pollution control

① Build green transport system and develop public transport

![Graph showing transportation usage in different cities]
## 2. Enhance vehicle pollution control

### ② Improve vehicle emission standards for new vehicles

<table>
<thead>
<tr>
<th>Country</th>
<th>95</th>
<th>96</th>
<th>97</th>
<th>98</th>
<th>99</th>
<th>00</th>
<th>01</th>
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<tbody>
<tr>
<td>European Union</td>
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<tr>
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Notes:
- \^italics \- under discussion
- a - gasoline
- b - diesel
- c - Entire country
- d - Delhi, Chennai, Mumbai, Kolkata, Bangalore, Hyderabad, Agra, Surat, Pune, Kanpur, Ahmedabad, Sholapur, Lucknow; Other cities in India are in Euro 2
- e - Beijing and Guangzhou (as of 01 September 2006) have adopted Euro 3 standards; Shanghai has requested the approval of the State Council for implementation of Euro 3
- f - Euro 4 for gasoline vehicles and California ULEV standards for diesel vehicles
- g - Gasoline vehicles under consideration
北京市强有力的机动车控制使得NOX总排放开始下降

- 2000年开始，北京市机动车NOx排放量开始逐步下降，最主要的减排效果来自于北京过去10年实施的国I-国IV的新车排放标准。
- 此外，北京过去针对重型车加速淘汰的政策也导致相当部分NOx排放的削减（见上图2001-2003年期间）
2. Enhance vehicle pollution control

③ Reduce the sulfur content and improve the fuel quality

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注：a: under consideration; b: Marketed

Source: Micheal P. Walsh
2. Enhance vehicle pollution control

④ Improve the I/M (inspection/maintenance) programs to effectively control in-use vehicle emissions

⑤ Promote clean vehicles and increase the proportion of clean energy
3. Reinforce SO2 emission control

Simultaneously reducing SO$_2$ Emissions from power plant and industrial boilers

- Reduction of SO$_2$ emission from Coal-fired industrial boilers will increase
- Reduction of SO$_2$ emission from Coal-fired power plants will decrease
4. Control NOx and VOC emissions

① Establish NOx and VOC emission control regulations
② Formulate NOx and VOC pollution control plan
③ Implement total emission control policy on heavy polluted industries, including power plants, iron and steel plant, and cement plants
④ Strictly control NOx emission from vehicles
⑤ Prevent VOC emissions from solvent use
⑥ Control VOC emissions from oil/gas station
5. Strengthen primary PM emission control

① Increase the use of washed coal

② Control particulate emissions from cement and steel industry through phasing out old production processes, recycling waste heat of dry kilns, installing high efficiency dust removal facilities and reducing fugitive dust emissions.

③ Install high efficiency dust collectors in power plants and industrial boilers

④ Control particulate emissions from agricultural area sources

⑤ Strengthen forestation to prevent sandstorms
6. Control ozone and secondary PM

① Strengthen researches on regional air pollution control strategies

② Establish scientific air quality standard and target

③ Develop an integrated multi-pollutant control programme including PM and its precursors (SO2, NOx, organic and elemental carbon), and ozone precursors (NOx, and VOC)

④ Establish regional coordination mechanism and management system
Regulation and Policy for BAQ

1. Improve air pollution control regulations

2. Emphasize the role of environmental economic policies

3. Strengthen international cooperation on global problems
1. Improve air pollution control regulations

① Amend “Air Pollution Prevention and Control Law”, enhance and specify legislative targets, enforcement, and legal responsibilities

② Establish systematic air quality and emission standards

③ Strengthen the application, issuance, approval and supervision of pollution emission allowance

④ Formulate the implementation plan and policies on emission cap and trade

⑤ Integrate environmental protection into other laws
2. Emphasize environmental economic policies

① Internalize the external costs of air pollution emissions
   a) increase the pollutant discharge fee
   b) apply fuel taxes on automotive industry

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2. Emphasize environmental economic policies

② Implement price policy in favor of energy conservation and emission reduction

   a) Differenciated price policy for energy-intensive industries

   b) Raise parking fees and fuel price to restrict vehicle uses

③ Implement SO2 and NOx emission trading program in power sector, establish emission allowance issuing system to push the enterprises control their pollution incentively
3. Strengthen international cooperation on global issues

Mercury as an example:

• Increase knowledge and capacity on mercury including emissions inventory, atmospheric mercury pollution, fate and transport

• Develop atmospheric mercury pollution control technology and reduce anthropogenic mercury emissions

• Establish mercury pollution management system

• Strengthen international cooperation
Acknowledgement

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Thanks for your attention!